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NUCLEAR POWER

ALTERNATIVE ENERGY

Policy Suggestions on Participation in International High-Tech Cooperation Presented

956B0004A Beijing KEJI DAOBAO [SCIENCE AND TECHNOLOGY REVIEW] in Chinese
No 7, Jul 94 pp 32-34

[Article by Cao Wei [2580 0251], Lecturer, Huaxing High-Technology Development Company, Daqing Petroleum Academy, Anda, and Dr Wang Chen [3769 3819], Technology Development Department, Weizhan International Corporation, Limited, Zhuhai: "Trends in International Cooperation and China's Policies Regarding Them"]

[FBIS Translated Text] High technology, spearheaded by microelectronics, is a subject of extensive interest to governments and manufacturers throughout the world. Because a country's high-technology R&D can greatly increase its scientific, technological, economic, military, and political strength and influence, the international competition in high technology has become extremely intense. Since the 1980's, the major countries of the world have drafted high-technology development programs in the hope of gaining the upper hand in the competition. The "Strategic Defense Initiative" (or "Star Wars") that the U.S. proposed in 1983, the "Policy Guidelines for Invigorating Science and Technology" drafted by Japan in 1983, the "European Research Coordination Structure" (or "Eureka Plan") developed by the European Community in 1985, and the "General Program of Scientific and Technical Progress for the Year 2000" signed by the former Soviet Union and the Comecon nations in 1985 (the "Eastern Eureka Plan") were plans for the development of high technology. In March of 1986, China's government drafted the "High Technology Research and Development (Outline) Plan," also called the "863 Plan," to serve as China's strategic program for catching up with the developed countries in high technology.

But in recent years, an entirely new trend has appeared in the technology field: large companies in such developed western countries as the United States, in Europe and Japan, and in certain newly emerging countries and regions of Asia have been engaging in cooperation on scientific and technological projects. This trend has attracted major interest in the international manufacturing and S&T communities.

I. In July 1992, the IBM Corporation of the U.S., the Siemens Corporation of Germany, and the Toshiba Corporation of Japan formally signed an agreement on cooperation in microelectronics technology, which specified that the three parties would jointly develop 21st-century semiconductor technology and would produce 256-megabit DRAM [dynamic random access memory] chips for computers. These large-capacity chips are expected to become available in 1998. Each chip will be capable of storing 256 million bits of data, equivalent to twice the size of the complete works of Shakespeare. This cooperative project, which required eight years of negotiation before an agreement was reached, involves very large investments: just the design and software development for the first 256-megabit memory chips will cost US$1 billion, and each production plant will cost an additional $10 billion. This so-called "256-Megabit Project" involves a joint development effort by more than 200 engineering and technical personnel from the three companies, to be carried out at a new semiconductor technology center built by IBM in New York. Also in July 1992, the Advanced Micro Devices Corporation (AMD) of the U.S. and the Fujitsu Corporation of Japan jointly announced a huge cooperation plan in which they will develop and produce an integrated ROM [read-only memory] and display chip. The companies will jointly invest US$700 million to build new plants and other production facilities, and in addition they will buy 5 percent of each other's stock as cooperation guarantees. According to BUSINESS WEEK, Texas Instruments Corporation of the U.S. has been cooperating with Fujitsu of Japan, and Motorola of the U.S. with Toshiba of Japan, in the development of memory chip technology since the late 1980s. In the field of new energy sources, corporations in the United States and Japan recently have been engaging in cooperative R&D work on marine thermal energy conversion in Hawaii. This technology makes use of the temperature difference between the sea surface and sea bottom to generate electricity and in addition produces fresh water as a valuable by-product.

Since the 1980s, enterprises in some newly emerging industrial countries and areas of Asia have also begun to engage in international technology cooperation. Particularly noteworthy are companies in Korea and Taiwan. In June 1989, Hitachi Corporation, one of Japan's three largest electronics corporations, and the Gold Star Corporation of Korea decided to engage in the joint development and production of a 1-megabit DRAM chip. This was the first instance of high-technology cooperation between Korean and foreign manufacturers. Slightly later, the U.S. HP company signed a high-technology cooperation agreement with Samsung of South Korea for the joint development and production of advanced computer workstations. BUSINESS WEEK reports that Acer, Taiwan's largest computer manufacturer, has reached an agreement with Texas Instruments to develop sophisticated semiconductor chips. This will make Taiwan the world's fourth-largest supplier of chips, behind Japan, the United States, and Korea: its output will exceed that of all electronics manufacturers in Europe.

It is noteworthy that Taiwan corporations have used acquisitions of high-technology companies in developed countries or the purchase of stock in such companies in order to gain badly needed high technology and to place their products directly on foreign markets. In 1990 and 1991, Acer of Taiwan used financing from multiple sources to acquire two Silicon Valley high-technology companies, Wyse Technologies and Altos Computer Systems, for which it paid US$170 million and US$94 million. By this acquisition, Acer gained Altos's patents for advanced UNIX computer networks. International experts believe that this represents a breakthrough for Taiwan's computer industry. In addition, Acer also bought the Digital Technology Company of Germany and the Qiakale [phonetic] Computer Company of Holland in order to gain access to the large German and Scandinavian markets. In August 1990, the Hualong [5478 7893] Microelectronics Corporation of Taiwan paid US$5.3 million to acquire a 10-percent share in the stock of the Xike [phonetic] Technology Company of California. By agreement, Xike

will provide Hualong with advanced semiconductor design technology. The world microelectronics industry has begun to enter a state of global interlocking and cooperation.

II. The trend toward international S&T cooperation is not accidental: it is closely related to new characteristics and new circumstances of scientific, technological, economic and social development. The main reasons for its emergence are as follows.

First, high technology is a new type of technology at the cutting edge of S&T development. Because it is sophisticated, is highly knowledge-intensive and intelligence-intensive, and involves difficult research and development, it requires that the best S&T personnel of manufacturers, research organizations, and schools and academies be focused on cooperative breakthrough efforts if it is to succeed. High-technology R&D involves many interpenetrating, mutually influencing application technologies and technical sciences. For example, the technology domain of microelectronics includes semiconductor physics, integrated circuit fabrication technology, new components and materials (high-speed gallium arsenide components, three-dimensional integrated circuits, superlattice components and the like), superconductivity (Josephson junction memory circuits), laser technology (optoelectronic integrated circuits), bioengineering (biopolymer chips), computer science, and the like. In addition, microelectronics R&D makes use of basic scientific theory in such fields as solid state physics, quantum physics, quantum chemistry, structural chemistry, molecular biology, modern mathematics, logic, and so on. For this reason, high-technology R&D depends on the combined efforts of S&T personnel from many fields, and no single organization is likely to achieve a breakthrough by itself. Because every country's scientific and technological development has some imbalances, and because all countries have their strengths and weaknesses, no one country's manufacturers are likely to be able to bring together sufficient domestic high-technology R&D personnel. It is clear that international cooperation in high technology is an inherent requirement of present-day S&T development. According to the 1991 statistics compiled by Dennis Simon [inferred from phonetic rendering] of the Fletcher Technology and International Relations Center at Tufts University, Japan alone has more than 5,000 R&D personnel working in the United States. We may forecast that as science and technology continue to develop, S&T cooperation between manufacturers in different countries will continue to intensify.

Second, not only is high-technology R&D difficult, but it requires large amounts of research funding, and the commercialization and industrialization of it requires huge sums. High-technology R&D therefore involves great risk, and companies must be prudent in their policymaking. In order to minimize risk, former adversaries in various countries have been joining together. As Mr. Weber [inferred from phonetic rendering], head of the Texas Instrument chip division, stated, learning how to spread risk is essential to survival. Besides, when manufacturers in different countries join together, their strength is multiplied, which makes it easier to raise venture capital on international money markets.

Third, commercialization of high-technology results will yield huge earnings from vast markets. The desire to turn high technology into profits as rapidly as possible and to expand their monopoly profits is one of the most important reasons why companies in different countries engage in high-technology cooperation. The return on investment in high-technology products is astonishingly high compared with traditional products. If the factory price per kilogram of output is taken as one for iron and steel, it is 5 for automobiles, 50 for color televisions, 1,000 for computers, and 2,000 for integrated circuits. The market for high-technology products is exemplified by the semiconductor memory market, which is growing steadily. The range of applications of integrated circuits was already broad in the early 1980's, when its breakdown was as follows: computers, 32 percent; communications, 14 percent; office equipment, 5 percent; industrial control, 7 percent; instrumentation, 6 percent; automotive, 4 percent; calculators, wristwatches and cameras, 8 percent; sound, television, and video recorders, 14 percent; military and other applications, 10 percent. The range of applications for integrated circuits is still expanding. Huge markets such as this will bring immense joint benefits to cooperating parties and will not harm any of them.

The involvement of western companies in cooperation in high technology is not necessarily appreciated and supported by governments. Actually, it has already caused some government officials a certain amount of uneasiness. In September 1992, a science committee of the U.S. Congress held hearings on U.S. semiconductor companies. The federal government had provided US$500 million to a joint high-technology consortium created by domestic semiconductor corporations, primarily to increase the ability of the U.S. to compete with Japan in integrated circuit technology. But now these semiconductor companies are encountering strong challenges from multinational alliances. International observers believe that U.S. legislators cannot long remain uninvolved. It appears likely that in response to current international political and economic arrangements, in combination with the industrial policies and technology development objectives of various countries, the governments will exert an indirect or direct influence on international cooperation in the high-technology sphere. But international cooperation in high technology is consistent with the trend toward internationalization of science and technology and globalization and unification of the world economy. It is to some extent an objective requirement for the development of productive forces. The globalization of the world economy is critical to the future development of international society. As former Singapore President Lee Kuan Yew stated at an international economic conference held at Davos in 1990, "In today's world, independence has become a flood tide, and economic growth is increasingly governed by global rather than regional factors." Clearly, the trend toward international cooperation in high technology will become stronger rather than weakening.

Cooperation in high technology allows companies in the developed countries to increase greatly their monopolistic position in high-technology products. In addition, the preliminary intellectual property agreement that, as a result of pressure from the United States and other western

countries, was adopted in December 1991 at the Uruguay Round of the multinational GATT discussions will further strengthen this monopoly position (see the article by Zhu Xuezhong [2612 7185 1813] in No. 1, 1994, of this journal, "Characteristics of the GATT Intellectual Property Agreement and China's Policy Toward It"). This will create even greater difficulty in resolving the long-standing problem of north-south relations. To summarize, the trend toward international cooperation in high technology will have future international political, economic, scientific, technological, and social consequences that cannot be ignored and that demand close consideration.

III. China must adopt an appropriate policy toward international S&T cooperation in order to make better use of its opportunities, to raise its scientific level as rapidly as possible, and to increase its economic strength. Self-reliance should of course be primary in the development of high technology in China, but this does not mean that we can neglect international cooperation. Actually, self-reliance can enable us to participate in international cooperation and competition, while at the same time, international cooperation can strengthen our capacity for self-reliance: the two aspects promote each other. It is clear from both theory and experience that it is only by an all-round involvement in international scientific, technological, and economic cooperation that a country can achieve optimized macroscopic allocation and rational flow of technological factors and production factors, obtain optimum economic results, and ultimately strengthen its competitiveness on international markets. Since reform and opening to the outside were begun, China has made great strides in S&T and in economic development, and its overall strength has increased considerably. This has created conditions favorable for China's participation in international S&T cooperation. We therefore make the following suggestions.

First, the relevant departments must draft policy measures and provide support to manufacturers and the S&T community so that they can actively involve themselves in high-technology R&D cooperation with the developed countries. Vigorous efforts to bring about the commercialization of results should be made, either by the use of foreign and domestic investment funds or by the purchase of controlling stock interests by the state. This type of cooperation will accelerate China's high-technology R&D and will bring economic benefits rapidly.

Second, domestic manufacturers with the ability to do so should follow the example of Taiwanese companies by acquiring foreign high-technology companies or buying partial shares or controlling shares in them in order to use the developed countries' advantages in science and technology, personnel and markets and to gain high technology that China needs. This method produces results rapidly and will be of major help in quickly raising China's level in certain areas of science and technology. By means of the acquisition method, certain enterprises in Taiwan have greatly increased their overall technological strength, and the results are regarded as highly satisfactory by Taiwan manufacturers and managers. As Ben Bean [inferred from phonetic rendition] of the Robertson and Stephens investment banking corporation in San Francisco stated, "The acquisitions of companies here (by the Taiwanese) are strategic." Acquisitions not only enable them to directly acquire relevant high-technology results or profits and to make use of science and technology personnel, but also enable them to use existing markets that have been developed by the companies they acquire. This point is extremely important. For example, when Acer acquired Altos, it used Altos's existing markets (1,500 distributors) to double its sales on the U.S. market to more than $250 million, while increasing its global sales to $1 billion. In addition, new computer models that Acer brought out were sold under the Altos trade mark. When pursuing an acquisition strategy, China should in general have a strong technology company lead the way, with other companies or research organizations cooperating by the purchase of stock. Some large- and medium-size state-owned enterprises in central and western China have solid technology personnel, while the coastal regions (especially the special economic zones) opened to the outside rather early and have abundant enterprise funds: thus, the two regions could make thorough use of their respective advantages by cooperating in an acquisition strategy. In terms of funding, and especially in terms of foreign exchange, the relevant departments should institute preferential measures in order to support these acquisitions. In addition, strong enterprises may consider raising funds on international financial markets. When Acer acquired Altos, it applied to the Bank of America and to Barclay's Bank for a temporary loan of US$80 million. We can learn a lesson from this event.

In addition, China should make a focused effort to train a contingent of senior personnel who understand science and technology but are also familiar with operations, management, and international practices, in order to meet the requirements of international high-technology cooperation. International high-tech cooperation requires specialized high-technology research personnel, but also appropriate high-level management personnel. International high-tech cooperation involves not only technology problems, but also problems in such diverse areas as science and technology management, technology trade (licensing), intellectual property, law, banking, personnel management, international practices, and it is essential that we not have a shortage of high-level management personnel. Such personnel could be trained by domestic institutions of higher education or the enterprises, with the cooperation of foreign specialized training companies or schools if necessary.

Finally, the cognizant government departments, manufacturers, scientific research organizations, and institutions of higher education should make use of existing overseas companies' or agencies' advantages in information, personnel, and international experience and should strengthen their ties with these organizations in order to carry on focused tracking of trends among the developed countries' technology manufacturers and in high-technology research; this will allow them to take better advantage of favorable opportunities and to gain rapid entry into the international high-technology cooperation arena.

Continuous Preparation of YBCO/Ag Superconducting Tapes by New MOCVD Reactor

956B0022A Beijing DIWEN WULI XUEBAO [CHINESE JOURNAL OF LOW-TEMPERATURE PHYSICS] in Chinese Vol 16 No 5, Sep 94 pp 329-332

[Article by Xie Wenyuan [6200 5030 0337], Yuan Fenchi [5913 7685 3069], Cheng Binji [4453 1755 0679], Chen Jiping [7115 4949 1627], Yang Guowen [2799 0948 2429] and Cui Bingxin [1508 3521] of Changsha Research Institute of Mining and Metallurgy, 410012, Changsha: "Continuous Preparation of YBCO/Ag Superconducting Tapes by New MOCVD Reactor"; funded by the National Superconducting Technology Combined Development Center; MS received 10 Apr 94]

[FBIS Abstract] A new MOCVD reactor with heated quartz wall is designed to prepare YBCO/Ag superconducting tapes. The reaction gases $Y(TMHD)_3$, $Ba(TMHD)_2$, and $Cu(TMHD)_2$ are heated and vaporized at 130°C, 235°C, and 126°C respectively. These gases and oxygen are mixed in a mixing compartment and then introduced to the precipitation chamber, whose quartz wall is heated to between 844°C and 855°C. The gases react, form YBCO, and precipitate on a silver substrate strip (1.6mm wide, and 0.3mm thick). The experiments are conducted in such a way so that YBCO can precipitate either on a stationary silver strip for 11 minutes, or on a silver strip moving at a speed of 15cm per hour. During precipitation, the chamber pressure is maintained at 0.67KPa. Then each specimen, the YBCO/Ag tape, is cooled at 14°C per minute to room temperature in an oxygen atmosphere with 101.3kP pressure.

The products are analyzed with XRD, SEM and EDS. The I_c (78K,OT) values of the YBCO/Ag tape products are measured with the four-point-probe method. The J_c of the tape (film thickness 0.8 μm; I_c = 349mA) prepared by the static method is $2.2 \times 10^4 A/cm^2$, and the J_c of the tape (film thickness 0.8μm; I_c = 223mA) prepared by the static method is $1.7 \times 10^4 A/cm^2$ (78K, OT). The transition temperature (T_c) of the tape by the static method is 88K.

SEM photo shows that the static tape displays a bright and dense surface with no apparent gaps and impurities. However, the crystals of 1μm to 2μm still arrange disorderedly. The moving tape displays a rough surface with more spaces among the crystals and very disordered arrangement.

EDS analysis reveals that the ratios of Y:Ba:Cu are 1:2.3:3.1 and 1:2.4:3.2 respectively for the static sample and the moving sample.

Four figures, no table.

References 5: 2 English, 3 Chinese.

Internal Losses in Nanoscale Al_2O_3 Solids

956B0022B Beijing KEXUE TONGBAO [CHINESE SCIENCE BULLETIN] in Chinese Vol 39 No 17, 1-15 Sep 94 pp 1554-1556

[Article by Xie Cunyi [6200 1317 30151, and Zhang Lide [1728 4539 1795], of Institute of Solid State Physics of Chinese Academy of Sciences, Hefei, 230031, and He Min [0149 2404], student of 93 class of Material Department of Anhui University, and Wen Yiting [2429 0076 3060] of Open Laboratory of Internal Friction and Solid State Defects of the China Science and Technology University: "Internal Friction in Nanoscale Al_2O_3 Solid"; Funded by the National Climbing Plan; MS received 27 Jul 93, revised 23 Apr 94]

[FBIS Abstract] The nanoscale Al_2O_3 test specimens (80mm x 4.5mm x 3mm) are pressed at 0.3GPa from powders made by the gel method. The specimens are annealed respectively at 700°C, 940°C, 1100°C, and 1180°C, for five hours. The heat treatments cause the transitions of Al_2O_3 from boehmite (as prepared specimen) to η-Al_2O_3+boehmite, to γ-Al_2O_3+η-Al_2O_3, to α+γ-Al_2O_3 and to α-Al_2O_3(corundum), respectively. These specimens and the non-treated specimen are tested for their internal friction properties and moduli, in a temperature range from -200°C to 50°C by the free-decaying sonic frequency method. Their moduli (bending mode) are measured by the resonance frequencies. The measuring procedure consists of a temperature lowering process (from room temperature to -200°C) and subsequently a temperature raising process (from -200°C to room temperature). The temperature changing rate is 1.5°C per minute.

The phase analysis is conducted with an X-ray diffractometer, and their particle sizes are determined with a transmission electron microscope.

The "internal friction vs. temperature" curves of the room temperature specimen as well as the specimens treated respectively at 700°C, and 940°C display two internal frequency peaks, P_1 and P_2. P_1 belongs to the relaxation type with an activation energy of 0.087eV. The formation of P_1 is caused by the oxygen vacancies existing in the solid interfaces among the η-phase nanoscale Al_2O_3 particles. Both P_1 and P_2 disappear when the specimen (specimen treated at 1100°C, or 1180°C) does not contain η-phase.

The activation energy of the P_1 peak is calculated as H = 0.087eV, while $\tau_0 = 1.2 \times 10^{-7} S^{-1}$.

The mechanism of P_2 formation (which occurs only near room temperature during temperature rising) needs further studying.

Three figures, one table.

References 5: 4 English, 1 Chinese.

Nanocrystalline Cu-Ni-Sn-P Alloy Prepared by Amorphous Crystallization

956B0022C Beijing KEXUE TONGBAO [CHINESE SCIENCE BULLETIN] in Chinese Vol 39 No 17, 1-15 Sep 94 pp 1581-1583

[Article by Zhao Jianping [6392 1696 1627], Li Jiangong [2621 1696 0501] and Wang Tianmin [3769 1131 3046] of Material Science Department of Lanzhou University, Lanzhou 730000, and Cao Guixun [2580 6016 1789] of Provincial Analysis and Test Center of Gansu, Lanzhou 730000: "Nanocrystalline Cu-Ni-Sn-P Alloy Prepared by Amorphous Crystallization"; Funded by National Natural Science Foundation; MS received 13 Nov 93]

[FBIS Abstract] Nanocrystalline Cu-Ni-Sn-P alloy is prepared by annealing amorphous strips (25μm thick, and

20mm wide) composed of (in percent) 9.6Ni, 4.1Sn, 7.6P, and Cu-balance. DTA study shows that the material has two exothermic peaks at T_1 = 439K (reaction: Amorphous → α-Cu + Cu_3P) and T_2 = 543K (reaction: Amorphous → Ni_2P), respectively. The crystal parameters are: α-Cu (fcc, a = 0.3165nm), Cu_3P (hexagonal, a = 0.6969nm, c = 0.7143nm), and Ni_2P (hexagonal, a = 0.5846nm, c = 0.3372nm). The XRD spectra, and the TEM electron diffraction patterns prove that these three crystal phases exist in the nanocrystalline alloy tapes. The TEM observations and XRD calculations show the same crystal size results: the averaged crystal size is 20nm, ranging from 10 to 25nm. The element Sn does not appear in either analysis. It is possible that Sn forms solid solution with Cu, or exists on the crystal boundaries as solute-doped boundaries.

According to Lu Ke, et al., the amorphous alloy contains both short-range order and mid-range order structures. It is composed of randomly oriented atom clusters of different sizes as well as single atoms. During crystallization, in addition to the diffusion of single atoms (the classical crystallization mechanism), the consolidations of the atom clusters due to shear or precipitation also result in nucleations and growths. The amorphous Cu-Ni-Sn-P alloy in this investigation also contains the randomly oriented Cu-Cu, Cu-P, and Ni-P atomic clusters. The nucleation and growth of α-Cu crystal results from the shear and precipitation of the Cu-Cu clusters. As soon as Cu-P clusters encounter the a-Cu phase, the growth of the Cu_3P phase will inhibit the growth of the α-Cu phase. The orientations of all the ordered clusters are random, therefore, the orientations of the formed crystals are also random.

Three figures, no table.

References 5: 4 English, 1 Chinese.

Formation of Fe-Sn, Cu-Sn Nanoscale High-Temperature Phases via Mechanical Drive

956B0022D Beijing KEXUE TONGBAO [CHINESE SCIENCE BULLETIN] in Chinese Vol 39 No 17, 1-15 Sep 94 pp 1626-1628

[Article by Yang Yuanzheng [2799 0337 2398] of Second Department of Mechanical Engineering of Huanan Science and Technology University, Guangzhou, 510641, and Institute of Metals, Chinese Academy of Sciences, Shenyang, 110015, Ma Xueming [7456 1311 7686] and Dong Yuanda [5516 6678 6671] of Department of Material Science and Engineering of Shanghai Engineering University, Shanghai, 200072, and Zhuang Yuzhi [8369 5148 2535] of Institute of Metals, Chinese Academy of Sciences, Shenyang, 110015: "Formation of Fe-Sn, Cu-Sn Nanoscale High-Temperature Phases via Mechanical Drive"; MS received 15 Dec 93, revised 9 Apr 94]

[FBIS Abstract] The nanoscale alloy powders with the composition of Fe-Sn, and Cu-Sn respectively are prepared by the mechanical alloying method—ball milling. The elementary Fe, Cu and Sn powders have averaged powder size of 75μm with purity greater than 99 percent. The weight ratio of balls to powders is 10 to 1. The final products are examined by X-ray diffraction analysis (XDA), transmission electron microscope (TEM), and differential thermal analysis (DTA).

XDA shows that the milled specimen $Cu_{90}Sn_{10}$ is a solid solution, with particle size of 23nm. Specimen $Cu_{70}Sn_{30}$ displays ε-phase; and $Cu_{50}Sn_{50}$, η-phase. Both ε-phase and η-phase are high temperature phases. Two exothermic peaks and one endothermic peak appear in the DTA curve of each specimen. The first peak indicates the internal stress relaxation; and the second peak, the precipitation of some atoms and the grain growth. The endothermic peaks in the $Cu_{90}Sn_{10}$ alloy and in the $Cu_{50}Sn_{50}$ alloy indicate respectively the melting of Sn in the mixture and the transformation of n-phase (740K). That the endothermic peak in $Cu_{70}Sn_{30}$ does not appear indicates the transformation temperature of ε-phase should be about 950K.

XDA shows that the milled Fe-Sn specimens have an averaged particle size of 16nm after 120 hours of milling. When the Sn content is below 40 atomic percent, Sn and Fe form a solid solution. The intermetallic compounds $Fe_{1.3}Sn$ and $FeSn_2$ exist in the $Fe_{50}Sn_{50}$ alloy. The DTA curves of the Fe-Sn alloy are similar to those of the Cu-Sn alloy.

Four figures, no table.

References: 10 English.

STM Study of Nanocrystalline $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ Surface Prepared by Amorphous Crystallization

956B0022E Beijing KEXUE TONGBAO [CHINESE SCIENCE BULLETIN] in Chinese Vol 39 No 18, 16-30 Sep 94 pp 1662-1664

[Article by Feng Songlin [7458 2646 2651] and Ren Minqin [0117 7044 4440] of Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, 100080, and Liu Tao [0491 3447], Xu Zuxiong [1776 4371 7160], and Ma Ruzhang [7456 1172 3864] of Department of Physics, Beijing University of Science and Technology, Beijing, 100080: "STM Study of Nanocrystalline $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ Surface Prepared by Amorphous Crystallization"; Funded by the Technology Open Laboratory of the Chinese Academy of Sciences and Doctorate Special Topics Science Research Foundation of the State Education Commission; MS received 12 Jan 94, revised 28 Apr 94]

[FBIS Abstract] Amorphous $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ alloy tape with a width of 10mm and a thickness of 40μm is prepared by the single-roll rapid solidification method. The tape is then heat-treated at 556°C for one hour in a high purity hydrogen protecting atmosphere, and subsequently etched with argon ions to remove the residual surface oxide. The specimen is examined with a scanning tunnel electron microscope (STM) with the following parameters: tunnel current, 0.5nA; sampling point, 20 x 20; scanning cycles, 0.7s and 0.4s for the scanning areas of 300nm x 300nm and 30nm x 30nm, respectively.

The observation is conducted on the bright side (the roll side) of each specimen. The amorphous specimen shows an uneven surface and cavities probably due to solidification or the trapped gas carried by the chilling roll. The

bright surface of the annealed specimen displays a topography resembling fish-scales, with a dimension of 30nm to 100nm, probably formed by local crystallization. The fact that scales are much larger than the internal crystals (10nm to 20nm) indicates that the crystallization mechanism on the surface alloy is quite different from that of the core alloy of the tape. This phenomenon can be explained as follows: the crystallization usually starts from the surface, and when the interior nuclei grow to the nanoscale size, the crystals in the two-dimensional crystallization area already reach fairly large sizes. Furthermore, Cu promotes the nucleation of α-Fe(Si) solid solution on the amorphous matrix within the tape, yet the segregation of Nb on the grain boundary inhibits the grain growth. Consequently, the crystals within the tape maintain a certain size in a large annealing temperature range (about 500°C to 600°C). When the small scanning area is in the atomic scale, STM reveals that the crystallized surface displays spherical or deformed spherical cluster structure coexisting with the amorphous chain structure. This observation indicates that the surface crystallization of the amorphous tape has a special crystallization characteristic.

Three figures (two STM photos in each figure), no table.

References 15: 11 English, 4 Chinese.

Microstructures of Crystallites in Nanocrystalline Ni-P Alloys

956B0022F Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 30 No 9, Sep 94 pp B413-B419

[Article by Sui Manling [7131 2581 7881], Liaison person of Department of Material Science and Engineering of Northeastern University, Shenyang 110006 and International Center for Materials Physics, Chinese Academy of Sciences, Shengyang, and Lu Ke [4151 2688] of National Laboratory for Rapid Solidification and Non-Equilibrium Alloys of Metal Research Institute of Chinese Academy of Sciences: "Study of Microstructures of Crystallites in Nanocrystalline Ni-P Alloys"; Funded by the State's Natural Science Foundation and Leader's Special Foundation of Chinese Academy of Sciences; MS received 13 Jan 94]

[FBIS Abstract] Nanocrystalline tapes with the composition of $Ni_{80}P_{20}$ (atomic percent), dimensions of 2.3mm wide and 20μm thick are made from amorphous tapes of the same composition. The nanocrystalline alloy contains two phases: Ni solid solution (fcc structure), and Ni_3P phase (bct structure). Eight groups of amorphous specimens are treated at eight different temperatures ranging from 570K to 648K for time periods varying from 255 minutes to 3 minutes, respectively. The treatment effects on the microstructure are studied with an X-ray spectrometer and a high resolution transmission electron microscope. The investigation obtains the following results:

(1) The sizes of both the Ni-P solid solution crystals and the Ni_3P crystals increase with the increase of the annealing temperature. The orientations of the two crystal types are fixed, in spite of the different treatment processes. The two phases exist alternatively. The arrangements are random and dense without defects such as micro-void. The averaged linear size of Ni is about 1.63 times of that of Ni_3P.

(2) The P contents in the nanocrystalline Ni solid solutions are 10 to 15 times higher than the P contents in the corresponding equilibrium states.

(3) The Ni_3P lattices in the nanocrystalline material are distorted with the reduction of the grain size. The reduction of the grain size increases the lattice parameter *a*, and decreases the parameter *c*. The volume of the space lattice increases with the decrease of the crystals grain size.

An analysis based on the thermodynamic theory concludes that the distorted phenomena are caused by the vacancy changes in the nanoscale crystals.

Fives figures, three tables.

References 13: 12 English, 1 Chinese.

Domestically Made 3-Inch Horizontal GaAs Monocrystal Developed

95P60098A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 13 Dec 94 p 1

[Article by Yuan Xiaoyang]

[FBIS Summary] Scientists at the State Semiconductor Materials Engineering Research Center of the Beijing General Institute of Nonferrous Metals have developed 3-inch-diameter (76-mm), 5-kg horizontal silicon-doped gallium arsenide (GaAs) single crystal. This type of crystal, developed with advanced techniques such as multiple temperature zones and computer automated control, is a key material used in fabricating optoelectronic devices such as semiconductor lasers, infrared detectors, and solar cells for space power supplies. Previously, only the U.S. and Japan had been able to manufacture 3-inch large GaAs single crystals.

Formation and Elimination of Cores in $Bi_{12}SiO_{20}$ Crystals

40100017A Beijing GUISUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 22 No 6, Dec 94 pp 579-585

[Article by Xu Xuewu, Liao Jingying, et al. of the Shanghai Institute of Ceramics, Chinese Academy of Sciences; (MS received 24 Apr 93)]

[FBIS Abstract] The BSO crystals, 35mm in diameter, pulled along <001>, <110>, <111> and <112> axes were dissected. The relationships among the darkened cores in the BSO crystals, growth direction, interface shape and growth of facets were revealed by methods of shadowgraph and microscopy. The mechanism of core formation and methods of core elimination were discussed. It is shown that the cores in the BSO crystals grown along <001> and <110> axes can be eliminated by selecting a proper rotation rate which makes the interface shape flat or concave, and that the darkened facet-cores can be effectively avoided by choosing <111> and <112> growth directions. The defects such as growth striation, constitutional supercooling, stress and dislocation are also discussed in the paper.

Defect and Growth of Facets in Bismuth Germanate Crystal

40100017B Beijing GUISUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 22 No 6, Dec 94 pp 586-591

[Article by Liao Jingying of the Shanghai Institute of Ceramics, Chinese Academy of Sciences and Bonnema P. de Boor RC of the RIM Laboratory of Solid State Chemistry, University of Nijmegen, The Netherlands; (MS received 30 Aug 93)]

[FBIS Abstract] The defects of bismuth germanate crystal grown by Bridgman method were investigated. The optical characterization methods were used in the study of the defects of transparent crystal in visible light and the near UV absorption topography method is used in the study of the defects and relationship between defect and growth facets because scintillant BGO crystals, when suffering radiation damage, have a high absorption coefficient for light of short wavelength. On the basis of the crystal habit and the mechanism of growth facet of BGO, finally ways of reducing or eliminating the growth of crystal facets and defects are suggested.

Twin-Star GPS Project Sees Further Advances

95P60097A Beijing BEIJING KEJI BAO [BEIJING SCIENCE AND TECHNOLOGY NEWS] in Chinese 17 Dec 94 p 1

[Article by Yu Zaozao]

FBIS Summary] "Real-time correlating receiving equipment" designed for China's "Twin-Star" Satellite Global Positioning System (GPS) has been certified by an expert group as being at the international state-of-the-art. This key piece of equipment, jointly developed by the Chinese Academy of Space Technology's (CAST) Institute 503 and the Changfeng [7022 1496] Surface Wave Company, uses 256-bit surface acoustic wave (SAW) devices to implement 1023-bit non-repeating pseudo-code intermediate-frequency (IF) correlation storage technology and video storage technology. IF and video processing gain are 36 dB.

Domestically Made TM Format Synchronizer, Rapid Viewing System Developed

95P60097B Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 19 Dec 94 p 1

[Article by Huang Anwen]

[FBIS Summary] On 8 December in a laboratory at the CAS Remote Sensing Satellite Ground Station, an independently developed instrument and an imported instrument simultaneously processed remote sensing satellite data. The former produced clear images with distinct stratification, while the latter produced fuzzy images with unclear stratification. This instrument, called a TM [thematic mapper] format synchronizer and rapid viewing system, now formally certified, can process data from complex TM compound frame structures. The instrument's reliability, anti-jamming capability and synchronization ability are stronger than those of the comparable foreign-made product. Only a few advanced nations such as the U.S., Japan, France, and Canada have hitherto been able to manufacture a format synchronizer; the CAS Remote Sensing Satellite Ground Station researchers were able to develop this equipment in an Eighth FYP Key S&T project beginning in March 1993.

Expert System for Spacecraft Tracking Systems Design Certified

95P60097C Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 49, 21 Dec 94 p 2

[Article by Jin Hongfu]

[FBIS Summary] The "spacecraft external tracking overall design expert system (STDES)" recently developed by the Luoyang Institute of Tracking and Communications Technology has been formally certified. The development of this expert system signifies the first time that artificial intelligence (AI) technology has been applied domestically to the overall design of spacecraft tracking and control systems. STDES includes a knowledge base, database, techniques library, inference engine, and human-machine interface.

Description of the SJ-4 Satellite

956B0046A Beijing ZHONGGUO HANGTIAN [AEROSPACE CHINA] in Chinese No 11, Nov 94 pp 13-15

[Article by Hu Qizheng [5170 0366 2973], Chen Xiannan [7115 9475 2809]]

[FBIS Translated Text] Abstract: In February 1994, the Chinese scientific satellite SJ-4 was launched into a geosynchronous transfer orbit by the LM-3A launch vehicle from the Xichang launch site. This 400-kg, spin-stabilized satellite was designed and built by the Chinese Academy of Space Technology within a period of two years. The satellite carries 6 instruments used for charged-particle measurements and radiation-effect experiments. Since its injection into orbit, the SJ-4 has been operating normally and transmitting engineering data and experimental data back to earth via the UFH link. The current operating status of the satellite and experimental results are presented in this paper.

The main mission of the SJ-4 satellite is to explore the space environment by making charged-particle measurements and studying radiation effects. The results provide valuable first-hand information for designing long-life, high-reliability space vehicles. The SJ-4 can also be used to perform on-orbit tests of new technologies and new components that may be used on the next-generation satellites. In addition, it provides an opportunity for exploring different approaches of designing small satellites.

On 8 February of this year at the Xichang launch site, the first test flight of the LM-3A provided an opportunity to launch the SJ-4 into a highly elliptical orbit with a perigee of 203 km, an apogee of 36,000 km, an inclination of 28.6°, and a period of 10 hours 40 minutes. Since its injection into this orbit, the SJ-4 has collected a large amount of data on the space environment as well as test data on new technologies.

I. The Satellite Segment

This 400-kg satellite has a cylindrical shape with a diameter of 1.6 m; the cylinder has two receiving antennas extending from its mid section. The satellite is nearly 2.2 m tall, including the UHF transmitting antenna located on top of the satellite.

The satellite consists of the following subsystems: the structural subsystem, the attitude measurement and stabilization subsystem, the power supply subsystem, the thermal control subsystem, the telemetry, control and antenna subsystem and the payload subsystem.

1. The structural subsystem

The satellite has a frame structure with a force-bearing column at the center; the instruments are located on the instrument panel in the mid section of the satellite; the sensors are distributed in the mid section as well as the top and bottom sections of the satellite. Twenty-five solar panels are installed over the cylindrical surface as well as the top and bottom surfaces. The conical surface at the bottom of the satellite is connected to the launch vehicle.

2. The attitude control subsystem

The satellite uses a spin-stabilized attitude control system to meet its mission requirements. As part of the launch sequence, satellite spin is automatically initiated once it is separated from the launch vehicle and injected into orbit. The satellite is equipped with analog sun sensors and two-axis magnetic field-strength meters to measure the satellite position relative to the sun vector and the geomagnetic field vector; this information is used to determine the satellite attitude in inertial space and to establish a reference measurement frame. The system also provides such information as the solar incident angle, the spin velocity and the nutational motion of the satellite. In addition, the magnetic field-strength meter can be used to perform on-orbit measurement of residual magnetism of the satellite.

Figure 1. Final Assembly of the SJ-4 Satellite

3. The power supply subsystem

Located on the satellite surface is a solar array containing more than 10,000 pieces of reflecting type solar cells which have a 12 percent energy conversion efficiency. The power supply subsystem includes the solar array and a group of 15 amp-hour cadmium-nickel batteries. In the sun-lit region power is supplied directly to the load by the solar array via a multi-stage split-current voltage regulator; the power is also used to charge the batteries. During the eclipse period, power is provided by the batteries via a boost regulator. Although the eclipse duration for a highly elliptical orbit can last more than 2 hours, by properly selecting the SJ-4's launch window, it is possible to keep the satellite's eclipse duration to less than 60 minutes over a 6-month period; the corresponding depth of discharge of the batteries is 25 percent. The bus-bar power provided by the power supply subsystem is 65 watts, and the bus-bar voltage is 27 volts; other voltages needed to operate the instruments are provided by the secondary power transformer.

4. The thermal control subsystem

The fact that the SJ-4 has little internal heat source and is exposed to large fluctuations in external heat flux due to its spin-stabilization and the highly elliptical orbit makes it very difficult to design the thermal control system. Based on the results of thermal analysis and thermal equilibrium tests, we have designed a system which uses primarily passive thermal control supplemented by auxiliary active thermal control. Specifically, to achieve thermal equilibrium, the exterior surface is mostly covered with materials with high absorptivity-to-transmissivity ratio (α_s/ε) and low transmissivity (ε); the interior surface is covered with multiple layers of insulation materials in order to reduce heat dissipation and to minimize fluctuations in cabin temperatures due to changes in the sun angle and in the eclipse duration.

5. The telemetry, control and tracking subsystem

A UHF telemetry and control system is used to perform satellite tracking, orbit determination, remote control and telemetry. A ground-based telemetry and control network performs the functions of real-time and delayed remote control, and data loading. A 1-watt telemetry transmitter is used to transmit engineering data and measured environmental data back to earth. During the orbit segment when the satellite is not visible to the ground station, the data is temporarily stored in the on-board buffer; when the satellite passes over the ground station, it is then transmitted to the ground via delayed telemetry. In order to increase the operating range, a double-helix antenna has been designed to provide sufficiently high gain ($\geq$0 dBi) within a 60° beamwidth in the meridian plane.

6. The payload

The payload of SJ-4 includes 6 detectors: the proton detector, the electron detector, the plasma detector, the electric potential monitoring unit, the static detector of single-particle event and the dynamic detector of single-particle event. These instruments are used to detect electrons, protons and heavy ions in space; they cover a very wide energy spectrum ranging from plasmas whose energy level is of the order of tens of electron-volts to cosmic rays whose energy level may be several hundred million electron-volts. They can also detect various charged particles in the ionized regions, and measure the effect these charged particles have on the spacecraft.

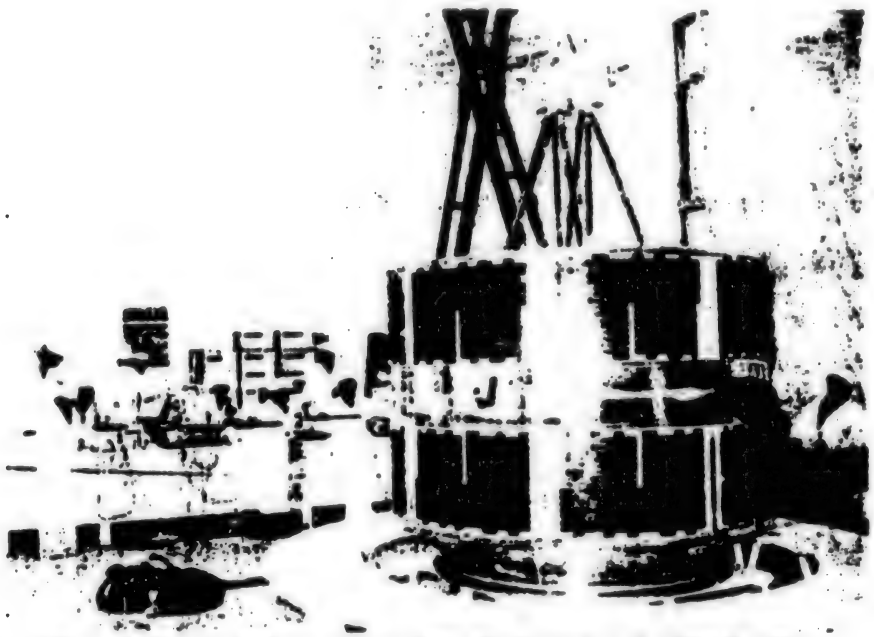

Figure 2. Electrical Measurements Being Performed on the SJ-4 Satellite

II. The Development Process

In December 1991, a decision was made to build the SJ-4; the goal was to develop the satellite in less than 2 years with limited funds. The satellite segment was to be developed by the Beijing Space Vehicle Design Department of the Chinese Academy of Space Technology, and the payload was to be developed by the Space Center of the Chinese Academy of Sciences.

Once the decision was handed down, the Space Vehicle Design Department immediately formed a research team to begin full-scale development of the satellite. Working under both time and fiscal constraints, the designers carefully reviewed and analyzed the development process, and implemented simplified procedures and stages wherever possible. Specifically, the traditional process of satellite development was replaced by a direct full-scale testing approach; as a result, the development cycle was significantly shortened without sacrificing quality.

The entire development process of this satellite took approximately 2 years. It can be roughly divided into 5 stages: feasibility study, design and production, final assembly and electrical measurement, full-scale testing (which includes mechanical and environmental testing, thermal-vacuum testing, quality and precision measurements), and field-testing and launch. After launch, the satellite transfers to the on-orbit operation and control stage.

The successful development of the SJ-4 is attributed in part to the many years of experience, technologies and equipment developed in building China's existing satellites, as well as to the new technological achievements from satellites currently development. Such an approach improves the reliability and reduces the development time and cost of the SJ-4 satellite; it allows members of the development team to devote their energies to solving the key technical problems of the new satellite. The success of this project is a reflection of the accumulated experience of the Beijing Space Vehicle Design Department in building China's 26 satellites.

III. Current Status of the SJ-4 Satellite

During the past few months since its orbit injection, the SJ-4 satellite has been functioning normally, and all on-board systems have performed as expected. The operating range of the telemetry and control system has exceeded design specifications; the tracking range is 40,000 km, and the telemetry receiving range is 35,000 km and the operating range of the remote control system exceeds 20,000 km along the visible segment of the orbit. At orbit injection, the satellite attained the desired attitude, and spin of the satellite was properly initiated at 21.6 rpm. The initial spin axis was pointed at the yellow pole. The initial nutation angle was approximately 1°. The temperatures of different parts of the satellite are maintained by the thermal control system to be within 10°-25°C.

The power supply system has been functioning normally to provide power to all the on-board instruments and equipment. The stable-voltage bus-bar system used by the primary power supply is a new system first used on Chinese satellites. During the sun-lit period, the solar array is connected to the split-current regulator, and during the eclipse period the batteries discharge to the boost regulator to maintain the bus-bar voltage in the range 27+/-1.5 volts (which exceeds design specification). The on-orbit operation of the power supply system provides valuable experience in designing this type of system for the next-generation satellites.

The flight test of hydrogen-nickel batteries is one of the new-technology tests conducted on this satellite. Hydrogen-nickel batteries have attracted world-wide attention because they are light-weight, and have deep depth-of-discharge and long life. After rigorous simulation tests and environmental tests on the ground, the hydrogen-nickel developed by the Ministry of Electronics are flight tested for the first time on the SJ-4 satellite. Prior to launch, the batteries are completely discharged; they remain inactive until 50 days after orbit injection, when they are brought on-line with the solar array to form the primary power supply system for the entire satellite. After several months of operation, the batteries have been subject to eclipse conditions lasting almost 60 minutes as well as full-sun conditions. The test results show that the voltage, current and temperature measurements under both charging and discharging conditions all agree with design specifications; also, a test has been conducted where charging of the batteries is controlled by a selectable V-T curve. Currently, the system continues to undergo operational tests. The preliminary flight test results will play an important role in promoting the use of hydrogen-nickel batteries on new space vehicles.

All the charged-particle detectors and environmental effect test equipment also functioned normally. The electron, proton and plasma detectors have provided large amount of data on the energy spectrum and spatial distribution of high-energy and low-energy electrons and protons. The electric potential monitoring unit has recorded a 2000-v surface potential. The static single-particle detector has detected average single-particle events of 3.4 times per day. The dynamic single-particle detector which uses a 80C86 chip as the central processing unit has detected higher frequency single-particle events.

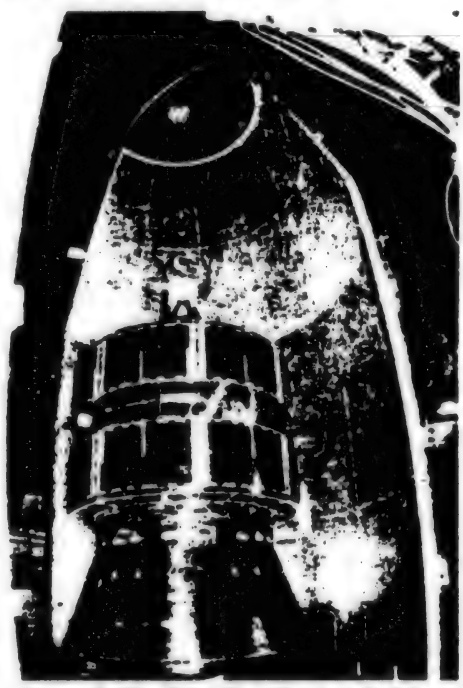

Figure 3. The SJ-4 Satellite in a Fairing

The SJ-4 satellite passes through the inner and outer radiation belts 4 times a day. While this provides a good opportunity for measuring charged particles in space, it creates a severe environment for satellite operation. On the 19th day, a serious incident of single-particle lock occurred; the CMOS circuit of the dynamic single-particle detector became locked up, and the electric current increased by 800 mA, causing overload in the secondary power supply and temporarily shutting off the power. After the Xian Control Center transmitted a remote command to the satellite, the circuit was unlocked, and the power supply was restored; subsequently, all the equipment returned to normal. So far, this satellite has captured 3 such single-particle lock events.

The test results from the SJ-4 satellite not only have given us a better understanding of the charged-particle environment in space, but also have provided valuable experience in designing large-scale integrated circuits for space applications.

Concepts for China, Asia Pacific Mobile Telecom Satellite Systems

956B0046B Beijing ZHONGGUO HANGTIAN [AEROSPACE CHINA] in Chinese No 11, Nov 94 pp 19-22

[Article by Min Changning [7036 7022 1380]]

[FBIS Translated Excerpt] Abstract: This paper briefly describes the current status and development trend of mobile communication satellite both at home and abroad. The basic design considerations for establishing a mobile communication satellite system for China and for the Asia-Pacific region are discussed. [Passage omitted]

According to government estimates, by the year 2000 China will have approximately 200,000 to 300,000 mobile users, of which 90 percent are domestic business users and 10 percent are private mobile users. The volume of China's mobile satellite communications will account for 40 percent of the total volume of mobile communications of the entire Asia-Pacific region. In addition, China's growing industrial activities in aviation, highway transportation, railroad and inland transportation, rescue and firefighting, and the developing remote regions also impose urgent demands on mobile satellite communication.

Because of its huge landmass and large population, China's mobile satellite communication market will be a hot spot of competition for the world's leading mobile communication satellite companies. Faced with this situation, it is important for China to establish an immediate policy to develop a regional mobile communication satellite system for domestic users and for users in the Asia-Pacific region.

In this paper, two plans for establishing a future mobile satellite communication system are proposed. The first is for a domestic mobile communication satellite system, which uses either China's own satellite platform or a foreign satellite platform (Plan A); the second is for a regional mobile communication satellite system for the Asia-Pacific region, which uses the modified Hughes-601 satellite platform (Plan B).

I. General Design Considerations

The design goal for both plans is to provide single-hop (or double-hop) satellite communication using a hand-held unit for the Chinese mainland and for the Asia-Pacific region. The objective is to satisfy the growing needs for mobile satellite communication for this region and to prevent the major international investors and corporations from taking over China's mobile satellite communications market.

1. Selection of the Communication System

The communication systems used by the mobile communication satellites that exist today are as follows: the IRIDIUM uses a combined TDMA/FDMA system; the GLOBAL STAR uses a combined CDMA/FDMA system; and the MOBILE STAR uses a combined single-channel per carrier (SCPC)/FDMA system.

The SCPC/FDMA system. This system has been widely used in VSAT communication; it is best suited for satellite transponder operation with no on-board processing; the system is voice-activated, and provides higher voice-channel capacity of the transponder. The voice channel has a bandwidth of 6 kHz, and uses quadrature phase shift keying (QPSK) modulation.

The TDMA/FDMA system. While the time synchronization of this system is rather complicated, TDMA users at the same frequency but different time slots can share the same modulator/demodulator; the system is best suited for a communication system that uses on-board switching. By using on-board voice insertion, the voice-channel capacity of the transponder can be increased.

The CDMA or CDMA/FDMA system. The CDMA system can increase the frequency re-use rate of a multiple-beam satellite-to-ground system; it can overcome the problem of inadequate beam separation and multi-path effects, and also provide improved security. The demodulation of CDMA is rather complicated, and it must be used in conjunction with bi-directional power control. The CDMA or CDMA/FDMA system can be considered where there is no on-board demodulation, modulation or processing.

Based on the above analysis, we have chosen the FDMA/TDMA system for the proposed plans. TDMA is primarily used for on-board processing to accomplish channel, frequency and beam conversion and distribution, and to perform demodulation and modulation for single-hop communication between mobile users.

The hand-held unit has two operating modes; it uses FDMA or TDMA to communicate with the satellite, but can use other systems to communicate cellular units on the ground.

The design of the signal correlation station should take into consideration the conversions between different communication systems. The signal correlation station carries out the conversions and ensures compatibility between the satellite system and the public telephone network as well as the cellular network.

2. Selection of Satellite Orbit

The mobile communication satellites that exist today are in one of three types of orbits: low-altitude orbit, mid-altitude orbit and geostationary orbit. Based on technical and economic considerations, a global mobile communication satellite system should use a mid-altitude or low-altitude orbit, whereas a domestic and regional satellite system should use a geostationary orbit. In terms of total system cost, the satellite system in a low-altitude orbit is the most expensive. For example, in the IRIDIUM system which has a large number of satellites, the total system cost is 3.4 billion dollars. Another factor that must be considered in orbit selection for a global communication system is the restrictions and regulations imposed by the regional or local government.

Because of the huge investment involved in a mid-altitude or low-altitude mobile satellite system, the fierce competition in the international market and the difficulty in the coordination and control of such a system, it is prudent for us to focus initially on a regional mobile communication satellite system in a geostationary orbit. This approach not only reduces the amount of required investment, but also gives China complete control over its satellite resources.

3. Selection of Frequency Band

Selection of the frequency band is dictated by the following two considerations: (1) the frequency band assigned by the International Radio Union for mobile communication, and (2) the problem of potential frequency interference. Based on these considerations and the communication requirements imposed by ships, airplanes and ground vehicles, a good choice for the frequency band of a mobile communication satellite system is as follows:

L band is used between the user and the satellite:

uplink: 1631.5 - 1660.5 MHz
downlink: 1530.0 - 1559.0 MHz

Ku band is used between the satellite and the feeder link of the signal correlation station:

uplink: 14000 - 14150(14240) MHz
downlink: 11450 - 11600(11690) MHz

The satellite operates in a "bent-pipe" mode. i.e., its bandwidth is 240 MHz when there is no on-board processing, and with on-board processing, it is 150 MHz.

4. Antenna Beam Coverage

The antenna beam coverage is primarily determined by the results of market survey, according to which China will have 180,000-270,000 mobile satellite users by the year 2000. If we postulate that 3 calls are made in a 9-hour day, and each call lasts 3 minutes, then the system will require 3412-5087 channels; if each call lasts 5 minutes, then 5644-8428 channels are required. China is developing increasingly closer ties with its neighbors in the Asia-Pacific region. Also, the development of the communications industry and the rapid economic growth of this region provide a solid foundation for the growth of the satellite mobile communications market. The total capacity of mobile communications in the Asia-Pacific region is expected to be 1.5 times China's capacity. Therefore, in the antenna design, a large antenna size and multiple point-beam technology should be used in order to achieve high antenna gain.

For the mobile user—satellite link, two configurations have been proposed: one configuration uses 10 point-beams (1.75° x 1.75°) to cover China's mainland and coastal regions, as shown in Figure 1; the other configuration uses 32 point-beams (1.75° x 1.75°) to cover the Asia-Pacific region, as shown in Figure 3. The satellite has two 8-m mesh antennas, one for transmitting and one for receiving. The Ku-band feeder link between the signal correlation station and the satellite uses a 0.9-m parabolic reflector antenna whose beam covers the entire country (or the Asia-Pacific region), as shown in Figure 2 and Figure 4. This design provides higher antenna gain and improves the overall effectiveness of the satellite system.

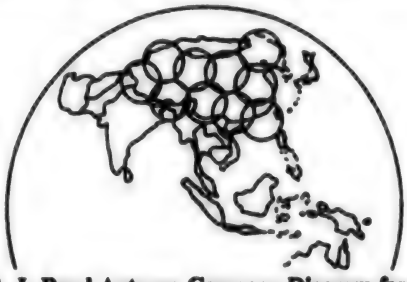

Figure 1. L-Band Antenna Coverage Diagram for Plan A

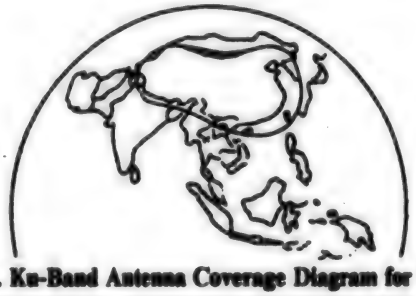

Figure 2. Ku-Band Antenna Coverage Diagram for Plan A

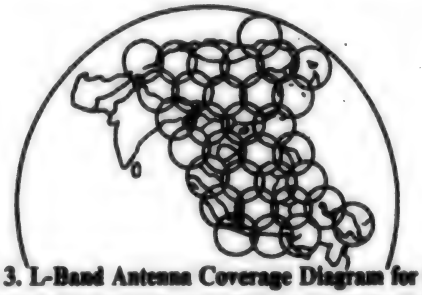

Figure 3. L-Band Antenna Coverage Diagram for Plan B

5. Selection of Orbit Position

Selection of the orbit position is dictated by the following considerations: the total area of coverage; the size of the coverage beam and pattern loss; the times at which the satellite enters and exits the earth shadow; the velocity correction required for station keeping; the coordination

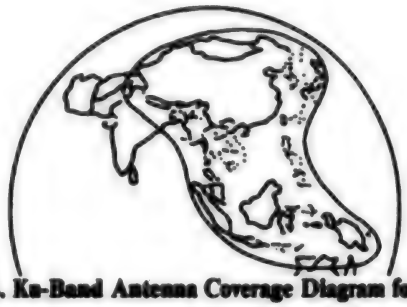

Figure 4. Ku-Band Antenna Coverage Diagram for Plan B

of the orbit position and potential interference with neighboring systems; and the requirement that the elevation angle of the entire service region must be greater than 20°.

Based on the above considerations, we recommend that the orbit position should be between 90°E and 100°E. Currently, there are only three satellites in the Asia-Pacific region (i.e., the Asia-Pacific 2, the Asia 2 and the Pan America 4) that are equipped with Ku-band transponders, and they are all located outside the longitude zone 90°E-100°E; they do not operate in the L-band. Therefore, coordination of the orbit position is not a problem.

II. Basic Performance of the Two Proposed Plans

1. Performance of the Satellite Segment

The satellite used for domestic mobile communication is placed in a geostationary orbit; the user link operates in the L-band and the feeder link operates in the Ku-band; it has 10-12 beams to cover the Chinese mainland as well as Hong Kong, Taiwan and the coastal regions; the satellite operates in a bent-pipe mode, and the communication system is SCPC/FDMA; it has two 8-m antennas, one for transmitting and one for receiving; the EIRP of the satellite is 64.1 dBW. The design goal of the satellite is to support double-hop communication from a hand-held mobile unit. There are a limited number of modulators and demodulators on-board the satellite to provide single-hop communication to some mobile users. The system can simultaneously provide communication links to 3000 hand-held terminals; the total capacity is 6000-8000 channels.

The satellite used for regional mobile communication for the Asia-Pacific region is also in a geostationary orbit; it has 32 beams to cover the southeast Asia region. The satellite is equipped with an on-board processing system which uses Fourier transform to perform channel, frequency and beam conversion and distribution as well as demodulation and modulation for single-hop communication between mobile users. The communication system is SCPC/FDMA/TDMA; the satellite has two 8-m antennas, one for transmitting and one for receiving; the EIRP of the satellite is 65.2 dBW. The design goal of the satellite is to support single-hop communication from a hand-held mobile unit. The system can simultaneously provide communication links to 4000 hand-held terminals; the total capacity is greater than 8,000-11,000 channels.

2. The Transponder and Its Operation

There are two types of transponders: forward transponder and backward transponder; the discussion here is limited to the transponders used in Plan B.

Forward transponder. The forward transponder consists of the beam forming network, the Ku-band low-noise amplifier, the down-converter, the on-board processor and the L-band up-converter, the by-pass filter, 2 groups (16 each) of 34-watt matrix amplifiers, and the beam forming network.

The function of the forward transponder is to transmit the information from the signal correlation station (including information sent by the fixed-terminal user to the mobile user and information received from the mobile user via the backward transponder) to the on-board processing channels of the forward transponder, and then to the mobile user terminals.

The information of the signal correlation station is divided into 4 groups, each group covering 8 beams; it is first sent to the beam forming network, where the signal is amplified by a low-noise amplifier, then down-converted to IF. One branch of the IF signal is sent to the Ku-band frequency converter of the backward transponder; the other branch is sent directly to the on-board processor and the demodulator-modulator, where it is distributed in channel, frequency and beam (which is controlled by the signal correlation station); the distributed signals are sent to the individual up-converters and filtered by the by-pass filter, then sent to the matrix amplifier. The amplified signal is sent to the high-voltage beam forming network.

Backward transponder. The backward transponder consists of the beam forming network, the L-band low-noise amplifier, the L-band down-converter, the on-board processor and the Ku-band up-converter, the power amplifier and the beam forming network.

The function of the backward transponder is to transmit the information from the mobile user (including information sent between the mobile users and information between a mobile user and a fixed user) to the on-board processing channels of the forward transponder, then to the mobile user terminal or to the fixed terminal of the signal correlation station.

The signal from the mobile user terminal is amplified by the L-band low-noise amplifier, and down-converted to IF; one branch of the amplified signal is sent to the on-board processor where it is redistributed and up-converted to L-band, then sent to the signal correlation station; the other branch is sent directly to the on-board processor of the forward transponder, where it is demodulated and modulated onto L-band; then it is filtered by a by-pass filter and amplified by a matrix amplifier, and sent to the user terminal.

A block diagram of the transponder is shown in Figure 5. The basic performance parameters of the satellite are presented in Table 1.

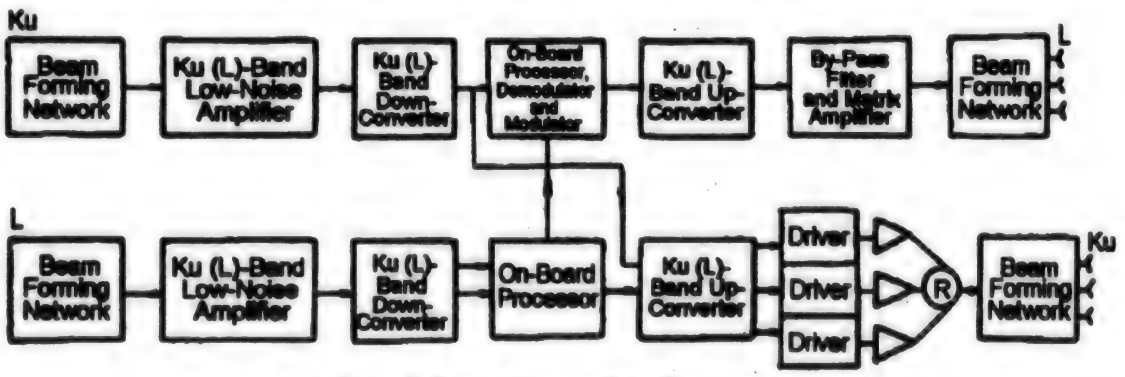

Figure 5. Block Diagram of the Transponder

Table 1. Satellite Performance Parameters

Performance Parameter	Domestic Mobile Satellite	Asia-Pacific Regional Mobile Satellite
Satellite platform	Domestic satellite common platform	Hughes-601 modified platform
Orbit position	90°E-100°E	90°E-100°E
Life	≥12 years	≥12 years
Orbit	Geostationary orbit	Geostationary orbit
Attitude stabilization	Three-axis stabilization	Three-axis stabilization
Launch vehicle	LM-2E and LM-3B	LM-3B
Antenna beam Ku:	One shaped beam covering all of China	One shaped beam covering the Asia-Pacific region
L:	Point-beams (10 1.75°x1.75°)	Point-beams (10 1.75°x1.75°)
Antenna dimensions	L: 2xΦ8.0 meter	L: 2xΦ8.0 meter
	Ku: Φ0.9 meter	Ku: Φ0.9 meter
On-board processor	No, can process a limited number of single-hop channels	Yes, can process 1000 single-hop channels
Satellite EIRP		
(Edge) L:	64.1 dBW	65.5 dBW
Ku:	41.1 dBW	41.1 dBw
Satellite G/T L:	9.5	9.5
(dB/°K) Ku:	0.8	-2.5
Satellite SFD L:	-120 - -130	-120 - -130
(dBk/°m^2) Ku:	-80 - -90	-80 - -90
Transponder bandwidth L:	29.0 MHz	29.0 MHz
Ku:	29.0 MHz	72.0 MHz
Communication capacity		
Hand-held unit	3000 systems	4000 systems
System	6000-8000 systems	8000-11000 systems

III. Key Technologies

The successful development of a mobile satellite communication system will require a series of new technologies which can be acquired through cooperative international ventures. These key technologies include:

1. Satellite-based large antenna technology. The L-band user link requires two 8-m antennas to support communication from hand-held units. The Ku-band uses shaped-beam antenna technology.
2. Multiple-beam technology. The domestic mobile satellite system requires at least 10 point-beams to cover the Chinese mainland and the Hong Kong Taiwan region; the Asia-Pacific regional mobile satellite system requires 32 point-beams to cover the entire Asia-Pacific region.
3. On-board processing technology. It involves the frequency, channel and beam distribution for the user channels and demodulation and remodulation of the signal channels.
4. Dynamic power distribution technology.
5. Bi-directional power control technology of the hand-held unit.
6. Dual mode operation of the hand-held unit.

AI-Language Integrated Environment GKD-CSE Certified

95P60100A Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONIC NEWS] in Chinese 30 Dec 94 p 3

[Article by Tan Keyang and Jia Yan]

[FBIS Summary] The "Client/Server Model Based AI (Artificial Intelligence)-Language Integrated Environment GKD-CSE" developed by 10 AI specialists at the Computer Institute of the University of Science and Technology for National Defense (USTND) was recently certified in Changsha by an expert panel from the State's 863 Program. The USTND group, led by Wang Pu [3769 2613], Prof. Gao Hongkui [7559 3163 1145], and Dr. Wang Huaimin [3769 2037 3046], has developed an AI tool integrated environment that supports mainstream techniques such as application programming interfaces (API), databases, and network communications. The AI tool includes a logical inference tool and a production-model inference tool.

Warship Stealth Technology Symposium Held at Naval Academy of Engineering

95P60104A Wuhan HAIJUN GONGCHENG XUEYUAN XUEBAO [JOURNAL OF THE NAVAL ACADEMY OF ENGINEERING] in Chinese No 4, Dec 94 p 29

[FBIS Summary] To promote naval strategic planning, to encourage R&D of new technologies, and to discuss warship stealth technology achievements already realized at the Naval Academy of Engineering, the academy held a "Warship Stealth Technology" symposium on 28 September 1994. Over 60 specialists attended the symposium, at which six papers were delivered and discussed. These six papers were: (1) First Department Prof. Guo Rixiu's [6753 2480 0208] "Advances in Warship Anti-Vibration and Damping Technology," (2) Second Department Prof. Shi Yin's [2457 1714] "Damping and Noise-Reduction Research and Stealth Technology," (3) Second Department Associate Prof. Pu Jinyun's [3184 6855 0061] "An Important Method for Improving a Warship's Ability to Exist—Stealth Technology," (4) Fourth Department Prof. Zhang Zhonglong's [1728 1813 7893] "Study of the Current Situation and Measures To Be Taken in Domestic Submarine Magnetic Stealth," (5) Basic Department Associate Prof. Huang Zhexun's [7806 0772 6676] "Discussion of Acoustic 'Black' Bodies," and (6) Basic Department Prof. Yao Shuren's [1202 2885 0086] "Research on Warship Acoustic Stealth Materials." Active discussions of these papers have led to early preparations for establishment of a "Warship Stealth Technology Research Center" at the academy.

High-Resolution Imaging With Wideband Millimeter-Wave Radar

956B0012A Shanghai HONGWAI YU HAOMIBO XUEBAO [JOURNAL OF INFRARED AND MILLIMETER WAVES] in Chinese Vol 13 No 4, Aug 94 pp 261-266

[Article by Fan Zhengfang [2868 2973 5364], Xu Xiaojian [6079 1420 0494], and Zhao Su [6392 4790] of the Beijing Institute of Environmental Features, The Second Academy, National Space Bureau, Beijing 100854, China; MS received 4 May 94]

[FBIS Translated Excerpt]

Abstract

The main features of a wideband coherent millimeter-wave (MMW) radar measurement system are introduced. The principle of high-resolution imaging is reviewed, and four different imaging algorithms are presented and their performances are compared. Experimental results of imaging a model aircraft are also presented.

Introduction

High-resolution microwave imaging technique is of considerable interest both in this country and abroad because it provides a clear display of the distribution of target scattering centers. It is an important tool for studying the electromagnetic (EM) scattering mechanism of a radar-illuminated target and the control of scattering characteristics. During the past decade, millimeter-wave (MMW) technology has undergone rapid development. This institute has developed a wideband coherent high-resolution radar imaging system using Chinese-built MMW equipment; this system has been used to conduct studies of high-resolution MMW imaging of aircraft targets.

In this paper, the main features of the system and the basic principles of high-resolution target imaging are reviewed. Four different algorithms used for NNW high-resolution radar imaging are discussed and their performances are compared.

1. Millimeter-Wave Radar Imaging System

A block diagram of the wideband coherent MMW radar imaging system is shown in Figure 1. The system uses a fully coherent radar; the high-frequency segment consists of three phase-locked loops: the HAW reference circuit, the local-oscillator circuit and the transmission circuit. The bandwidth of the transmitted signal is 1000 MHz; the nominal range resolution is 0.15 m; and a frequency-hopping continuous-wave (CW) is used as the primary waveform. The receiver can simultaneously receive both horizontally polarized and vertically polarized (or left-hand circularly polarized and right-hand circularly polarized) signals, and measure the amplitude and phase of radar returns by performing phase detections in both I and Q channels. The key performance parameters of the system are as follows: operating frequency = Ka-band; signal bandwidth = 1.0 GHz; output power = 1000 mW; transmitted signal type, frequency-hopping CW; antenna

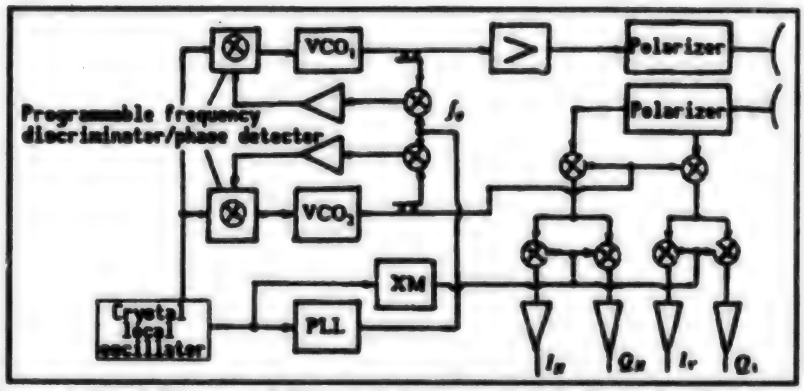

Figure 1. Block Diagram of Wideband Coherent MMW Radar Imaging System

polarization horizontal/vertical and left-hand circular/ right-hand circular; polarization separation ≥ 30 dB; receiver type, polarized dual-channel and I, Q dual-channel coherent receiver; receiver sensitivity = -100 dBm; receiver linear dynamic range ≥ 70 dB; amplitude measurement accuracy better than 1 dB; phase measurement accuracy, better than 10°.

2. Principle of High-Resolution Imaging

2.1 Basic Principle of Imaging

According to electromagnetic theory, under the conditions of physical optics and Born approximation, by measuring the monostatic or bistatic scattering fields of the target at different frequencies and different target attitudes, one can obtain the Fourier spectrum

of the target scattering function

$$F(\vec{p})$$

are the three-dimensional vectors in the Fourier space and

$$f(\vec{r}), \text{ where } \vec{p} \text{ and } \vec{r}$$

the target space respectively. Because of the band-pass characteristics and the high-frequency characteristics of the imaging system, and the finite observation window, the Fourier spectrum obtained from the actual measurements must be the expansion of the finite spectrum in the high-frequency region. In the high-frequency region, the target scattering function

can be interpreted as the three-dimensional geometric

$$f(\vec{r})$$

distribution and strength (RCS) distribution of those scattering centers which contribute to the measurement. Therefore, the reconstructed target scattering function is limited by the effects of diffraction and noise; the image created is an image of the multiple scattering centers.

The high-resolution imaging of the scattering centers is based on the principle of range-Doppler resolution. The imaging of target scattering centers is generally accomplished by rotating the target on a turntable. The nominal range resolutions in the radial and lateral directions are respectively:

$$\delta_y = \frac{c}{2B} \quad , \qquad (1)$$

$$\delta_x = \frac{\lambda}{2\theta} \quad , \qquad (2)$$

where B is the radar bandwidth, c is the speed of light, λ is the center wavelength, and θ is the total turn angle of the target. [passage omitted]

2.3 Sampling Interval in Frequency and Angle

In an actual imaging system, the measurement of frequency and target turn angle is accomplished by discrete sampling. To simplify the discussion, the algorithms presented below are expressed in the form of continuous integral given in the imaging formula; however, the sampling interval must satisfy the sampling theorem in order to avoid range ambiguities.

In a CW system, the sampling interval in frequency Δf must satisfy the following condition to avoid range ambiguity in the radial direction:

$$\Delta f \leq \frac{c}{4R_{max}} \quad , \qquad (7)$$

where R_{max} is the maximum range of the target, and c is the speed of propagation.

To avoid range ambiguity in the lateral direction, the sampling interval in azimuth Δ>v must satisfy the condition:

$$\Delta\theta \leq \frac{\lambda_{min}}{2D} \quad , \qquad (8)$$

where D is the size of the target, λ_{min} is the minimum radar wavelength.

3. Imaging Algorithms

The following four imaging algorithms have been proposed[2]: the two-dimensional Fourier Transform algorithm, the filtered backprojection algorithm, the maximum-entropy algorithm, and the hybrid artificial neural network algorithm. The two-dimensional Fourier Transform is the classical algorithm; the filtered backprojection algorithm is best suited for near-field imaging because the mathematical formulas contain near-field correction factors; these two algorithms can produce conventional high-resolution images. The maximum-entropy algorithm and the hybrid artificial neural network algorithm are nonlinear algorithms; both can produce super-resolution images.

3.1 The Two-Dimensional Fourier Transform Algorithm

The imaging data collected by rotating the target are given, polar coordinates (circular spectrum). However, the two-dimensional Fast Fourier Transform (FFT) algorithm is carried out in a rectangular coordinate system; therefore, prior to image reconstruction, the circular spectral data must first be converted to values on a rectangular grid based on the measurement geometry using a two-dimensional interpolator. [passage omitted]

3.3 The Maximum-Entropy Algorithm

The maximum-entropy algorithm is widely used in the estimation of high- resolution power spectra of discrete time series. In particular, for a short time series, this algorithm can enhance the resolution by extending the series outward. In microwave imaging, the two-dimensional target resolution is determined by the window size of the frequency spectrum and the azimuth angle. When the radar bandwidth is narrow or the azimuth

window is small, the resolution of the images may degrade significantly. Therefore, by using the maximum-entropy linear-prediction method to perform spectral extension of the measured data before reconstructing the target image, it is possible to achieve high-resolution microwave images with a small amount of measured data. The implementation of the maximum-entropy algorithm is given in Reference 2; the main steps of the algorithm are as follows:

(1) Apply the Burg algorithm to perform two-dimensional spectral extension of the measured frequency-azimuth data;

(2) Apply the filtered backprojection algorithm before and after spectral extension of the data to obtain a primitive image and a maximum-entropy image;

(3) Use the coarse information of the target "shape" provided by the primitive image to suppress the sidelobes of the maximum-entropy image, thus completing the final image reconstruction.

3.4 Hybrid Artificial Neural Network Algorithm

In practice, it is often required to perform target imaging with small turn angles. In this case, if the maximum-entropy algorithm is used for two- dimensional image processing, generally a large number of frequency sample points are taken, and a higher-order linear-prediction model in the radial direction can be selected, hence the prediction error is quite small; however, the number of sample points in the azimuth direction is quite small, hence the order of the linear prediction model must also be small, resulting in large prediction error. This error is the main reason that leads to degraded resolution and rising sidelobes. In order to overcome this difficulty, a hybrid image processing technique which combines the spectral extension algorithm in the radial direction and the artificial neural network algorithm in the lateral direction is used. The implementation of this technique is described in References 2 and 3; the main steps of this algorithm are as follows:

(1) Use linear prediction to perform one-dimensional spectral extension of the frequency samples below each azimuth angle, then apply Fourier Transform to obtain super range resolution in the radial direction;

(2) Determine the smallest mean square error of the estimated amplitude and phase of the scattering centers of each range cell in the lateral direction;

(3) Determine the locations of the scattering centers of the target using the Hopfield neural network model;

(4) Based on the locations of the scattering centers obtained from the previous step, the amplitude and phase of the scattering centers are re- computed to produce the final two-dimensional super-resolution image.

4. Experimental Results

As an example of the imaging process, the image of an aircraft model is reconstructed, as shown in Figure 2. The conditions of this experiment are as follows: radar operating frequency, Ka band; signal bandwidth = 1.0 GHz; target turn angle = 3°; angular sampling interval = 0.1°. By illuminating the target with vertically polarized waves, the co-polarized and cross-polarized components of the scattering field are received and processed using the filtered backprojection algorithm to reconstruct the co- polarized and cross-polarized images (Figure 2(a) and Figure 2(b)). Since the imaging system can measure both the co-polarized and cross-polarized scattering components of the target, the result can be improved by using polarization image-enhancement techniques. The conventional approach is to add the images formed by the Fourier spectra corresponding to the four elements of the scattering matrix to form an enhanced image. Another approach is to apply a symmetry image-enhancement technique by making use of the axial symmetry of the target; the plane of symmetry can be determined from the direction of the target motion. The images after polarization enhancement and symmetry enhancement are shown in Figure 2(c) and Figure 2(d), respectively.

The same data have been processed using the filtered backprojection algorithm (which essentially gives the same

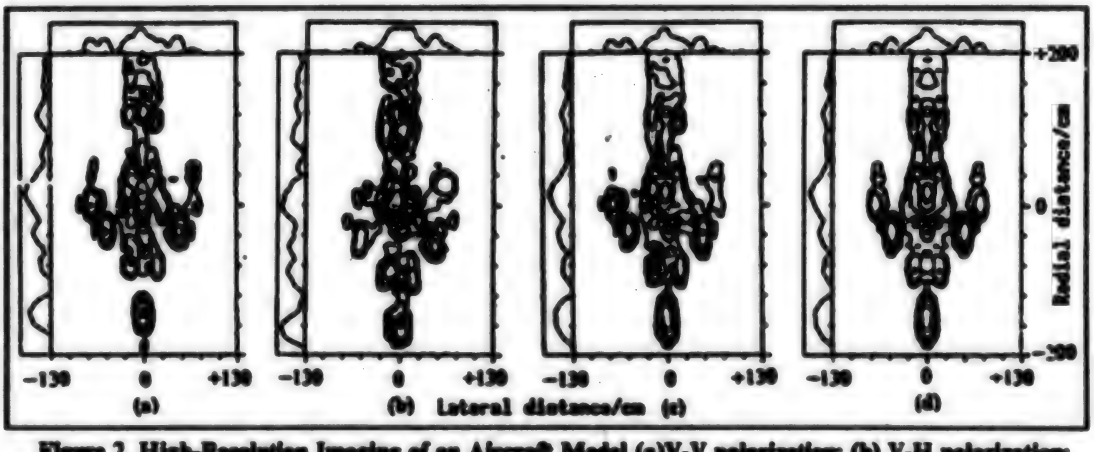

Figure 2. High-Resolution Imaging of an Aircraft Model (a)V-V polarization; (b) V-H polarization; (c) polarization enhancement; (d) symmetry enhancement

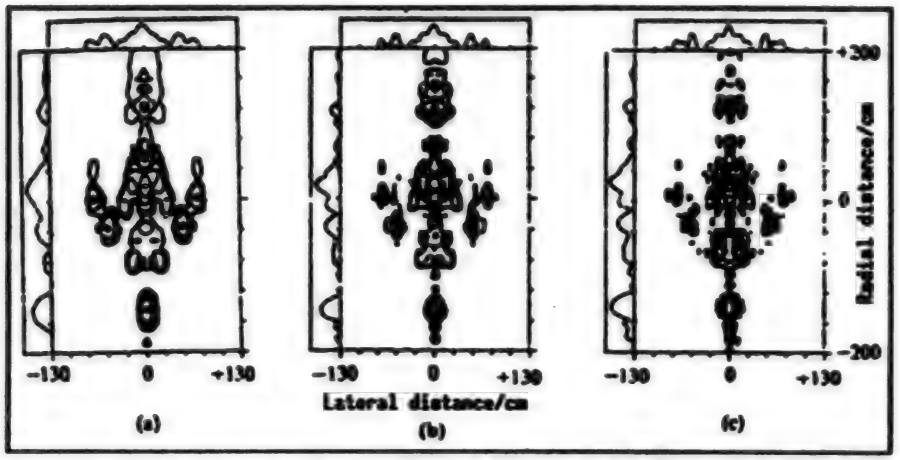

Figure 3. Reconstructed Images Using Three Different Algorithms (a) filtered back projection algorithm; (b) maximum-entropy algorithm; (c) hybrid artificial neural network algorithm

result as the 2-D FFT algorithm), the maximum-entropy algorithm and the hybrid artificial neural network algorithm; the reconstructed images from the three algorithms are shown in Figure 3.

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EM Scattering Analysis, Simulation of Complex Aircraft Targets

956B0012B Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese
Vol 22 No 9, Sep 94 pp 70-75

[Article by Wang Baofa [3769 1405 4099] of Beijing University of Aeronautics and Astronautics, Beijing 100083, and Liu Tiejun [0491 6993 6511] of the Beijing Institute of Environmental Features, Beijing 100854; MS received Dec 92, accepted Jun 93]

[FBIS Translated Excerpt]

Abstract

A method of analyzing and calculating the Radar Cross Section (RCS) for complex aircraft targets is presented. In this method, the target geometry is modelled by fitting its exterior surface using spline functions and dividing the surface into small finite elements. Physical optics approximation is used to calculate the scattering field for each element, and the overall scattering field of the target is obtained by phase synthesis. The validity of the method has been verified using mathematical models of aircraft targets. The discussion presented in this paper is limited to the case of monostatic scattering of a perfectly conducting metallic target.

I. Introduction

Over the years, many countries around the world have been actively conducting basic research on one of the key military technologies: stealth technology. Of particular interest in stealth technology research is contour stealth technology.

The main function of contour stealth technology is to design the components and exterior shape of an aircraft so as to minimize the radar cross section (RCS) while preserving its aerodynamic characteristics. In addition to the aerodynamic constraints the effectiveness of contour stealth technology also depends on the frequency. In the high-frequency region, the RCS of a scattering body is very sensitive to changes in the exterior shape, which makes contour stealth technology very effective. The effectiveness of stealth technology increases with frequency. But at lower frequencies, where the dimensions of the aircraft are of the same order of magnitude or smaller than the wavelength, changing the exterior shape of the aircraft can no longer reduce its RCS. Therefore, contour stealth technology is subject to a frequency limit determined by the dimensions of the aircraft.

Even in the high-frequency region, contour stealth technology is also subject to spatial constraints. In other words, changing the design of the aircraft components or its exterior shape can achieve RCS reduction only in a limited pie-region; furthermore, the reduction in RCS in one region will necessarily cause increase in the RCS in other pie-regions. The reason is that a simple change in the exterior shape of an object can only change the spatial distribution of the scattered electro-magnetic (EM) energy; it cannot reduce the total amount of scattered energy. Therefore, the purpose of modifying or re-designing the exterior shape of an aircraft is to re-direct the scattered EM energy away from the pie-region that is most vulnerable to radar detection to a less vulnerable region. Therefore, first

one must determine the vulnerable pie-region of the aircraft; generally, it is a region within a certain spatial angle of the nose cone of the aircraft.

Contour stealth technology is based on an analysis of the EM scattering mechanisms of various parts of the aircraft. In the high-frequency region, the total scattering field of a complex object can be regarded as the superposition of fields of many local scattering sources. These local scattering sources are called scattering centers. Scattering centers at different parts of an aircraft have different mechanisms. For a typical metallic scattering body, the known scattering mechanisms include: mirror reflection, edge diffraction, tip diffraction, creeping-wave along a curved surface, cavity scattering and traveling-wave effect of a. slender object. In this paper, a surface-element method is presented to analyze the radar scattering characteristics of a fused wing-fuselage structure, and to calculate the theoretical RCS value.

II. Analysis of the Exterior Features of an Aircraft

Generally, the structure of an aircraft has the following components: the fuselage, the wing, the horizontal tail, the vertical tail, the engine, the cockpit, the appendages and the landing-gear compartment. The exterior shapes of modern aircraft have become increasingly more complex, with a wide variety of different configurations. For example, the tail-less aircraft, the canard configuration, the dual-fuselage configuration, and the fused wing-fuselage configuration have all been used in aircraft designs.

In establishing the mathematical model of a complex aircraft, one must first establish a model for each component based on its exterior features, then synthesize them into a mathematical model for the entire aircraft.

To ensure smooth aerodynamic characteristics of its components, one can impose the condition of continuous first derivatives of its longitudinal cross section. For those components that are critical to the overall aircraft such as the wing and the tail, one should also impose the condition of continuous second derivatives of the longitudinal cross sections. To ensure smooth transition at the joints of different components, particularly the joints between the wing and the fuselage, a more stringent condition must be imposed. Furthermore, the model must also satisfy the requirement of mathematical uniqueness and completeness.

In general, aircraft components can be divided into the following three categories:

(1) Fuselage and Short Compartment

The fuselage is typically a slender body that consists of a series of parallel cross sections; the transitions between the cross sections must be smooth. The shapes of the cross sections vary according to some specific formula in the longitudinal direction; the trace of the variation defines the exterior- shape. Since such components are symmetric with respect to its axes, only half of the data points are needed to define the shape.

(2) Wing Surface

A wing surface typically has three segments: the wing-tip segment, the ruled-surface segment and the fairing segment. The main part of the wing consists of the ruled-surface segment; it is a surface which may have one or more generating surfaces. In general, one cannot ensure continuous derivatives between the generating surfaces. The generating surfaces are defined by standard airfoil shapes which are expressed in terms of a set of discrete form-value points. The coordinates of the form-value points are normalized with respect to the chord length; generally, the chords of two standard airfoils are located in the same plane to form the chord surface of the wing; this is called an un-twisted wing. A twisted wing surface is modelled by applying a transformation to the untwisted wing surface.

(3) Special Surfaces

In addition to the two surfaces described above, there are special surfaces which must be modelled according to their special shapes. For example, at the joint of the wing and the fuselage is a complicated fairing section (concave surface). To establish a mathematical model for such a surface requires the selection of appropriate boundary conditions to ensure smooth transition between the wing and the fuselage; thus, the first derivatives at the base of the wing and at the intersection of the fuselage and the transition surface can be chosen as the boundary conditions for the transition surface.

III. Mathematical Algorithm for Fitting the Exterior Surface of the Aircraft

The exterior surface of an aircraft can be modelled using a wide range of different mathematical algorithms. Each algorithm has its unique features and range of applicability. In order to implement the aerodynamically compatible "surface element" method to calculate the RCS, we have incorporated the requirements of CAD/CAM techniques in analyzing the exterior surfaces of an aircraft. Specifically, a third-order spline function is used to fit the surface, and the (Kong-Si) surface-element method is used to reconstruct a bit-cubic surface. Our basic algorithm is to use a three- parameter spline function to construct the ruled surface, then use a third- order spline function to construct the curves and surfaces. This method ensures that each point passes through the form-value points, and it can accommodate nodal points and nonuniformly distributed form-value points. This method can be used to model curves with infinite derivatives and twisted curves; it can also fit multi-valued curves and closed curves while satisfying the condition of continuous second derivatives over the entire curve; the shape of the fitted curve is geometrically invariant, it does not change with different coordinate systems. [passage omitted]

IV. Theoretical Analysis and Calculation of the RCS of a Fused Wing-Fuselage Structure

It is well known that the main contributions to the scattering field of a fused wing-fuselage structure are due to edge scattering and surface diffraction. Edge scattering can be modelled by the familiar UGTD method; however, modelling surface diffraction, particularly diffraction over a concave surface is a very difficult problem. In this paper, we use the surface-element method to determine the RCS

of a concave fused wing- fuselage structure. Specifically, the exterior surface is first fitted with spline functions, then divided into small surface elements; the selection of the elements depends on the geometry of the surface, the direction and polarization of the incident waves, and the attitude of the aircraft. The contribution of each element is calculated using physical optics approximation, and the total RCS of the target is obtained by the process of phase synthesis. [passage omitted]

V. Conclusion

The above algorithm has been used to determine the RCS of an elongated ellipsoid, a cylinder and a certain stealth target. Figure 3 shows the calculated RCS for the elongated ellipsoid. Figure 4 shows the surface element configuration of the stealth aircraft, and Figure 5 shows the calculated RCS of the stealth aircraft.

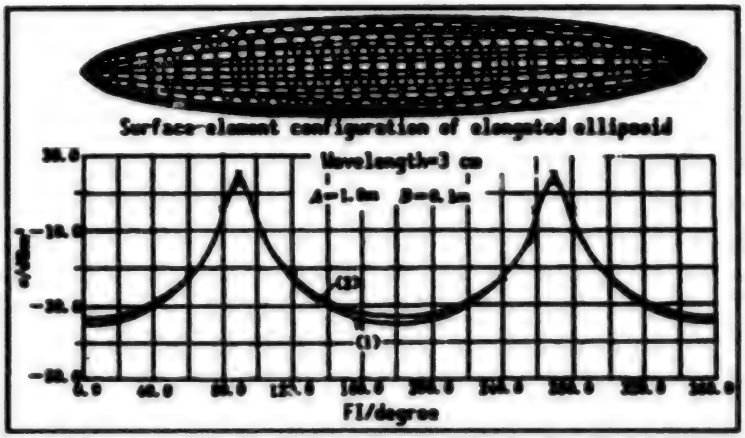

Figure 3. Comparison of RCS Calculations for the Elongated Ellipsoid. (1) Calculated results based on the integrated ellipsoid; (2) Calculated results based on the surface-element method

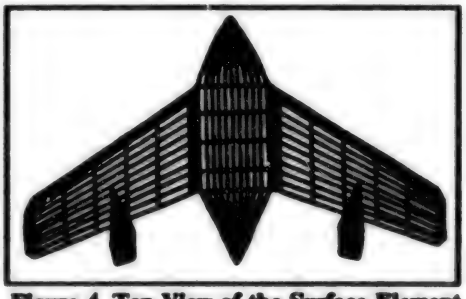

Figure 4. Top View of the Surface-Element Configuration of the Stealth Model

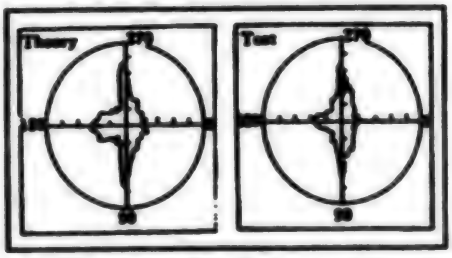

Figure 5. Theoretical Calculations and Experimental Results of a Stealth Aircraft (F = 8.8 GHz; vertical variation: Max = 20 dB, Min = -30 dB)

From the above results, one can make the following observations:

(1) Since the dimensions of the scattering body are much greater than the wavelength and the distance between the observation point and the source is much larger than the target, the use of physical optics approximation and the surface-element method is justified. The separate treatment of the surface effect and the edge effect (which can be treated by the GTD method) is a very useful approach in RCS calculation.

(2) From the RCS results of the stealth target, one can see that the fused wing-fuselage design is an effective approach in reducing RCS.

(3) In the design of the fused wing-fuselage structure, one can select the geometry of the structure by minimizing the scattering cross section of the target. This data can be used to compute the RCS values for different aerodynamic designs, different aircraft configurations, different polarizations and frequencies; the results can be incorporated into a basic module of the CAD/CAM system for aircraft and space vehicles. This module can be used in conjunction with other CAD modules in selecting optimum parameters for the design of aircraft and space vehicles.

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Liu Tiejun: Born 1941, graduated in 1960 from the Taiyuan Engineering College. Currently he is a senior engineer at the Beijing Institute of Environmental Studies; his primary research areas include: EM scattering of complex objects, back-scattering and CAD techniques. EM propagation and scattering in plasma and turbulent medium. He currently serves on the editorial committee of DIANZI XUEBAO."

High-Speed 1x4 InGaAs/InP PIN Photodiode Array With Monolithically Integrated Lenses

95P60092A Shanghai HONGWAI YU HAOMIBO XUEBAO [JOURNAL OF INFRARED AND MILLIMETER WAVES] in Chinese Vol 13 No 5, Oct 94 pp 364-368

[Article by Xiao Deyuan [5135 1795 0337], Ren Congxin [0117 3827 2946], and Chen Xueliang [7115 1331 5328] of the CAS Shanghai Institute of Metallurgy, Shanghai 200233: "High-Speed 1x4 InGaAs/InP PIN Photodiode Array With Monolithically Integrated Lenses," supported by grant from the Youth Foundation of the CAS Shanghai Institute of Metallurgy; MS received 17 Sep 93, revised 29 Mar 94]

[FBIS Abstract] High-speed 1x4 InGaAs/InP PIN photodiode arrays with integrated lenses have been fabricated by a multi-step process including liquid phase epitaxy, photolithography, and ion-beam milling. As measured with a 1.3-micron InGaAsP/InP double-heterostructure laser diode as the light source, detector pulse rise time is 360 ps and pulse full width at half maximum (FWHM) is 300 ps, giving a corresponding modulation bandwidth of 1.0 GHz; this is equivalent to 1 Gb/s reception of modulated data. Also, responsivity measures 0.5 A/W and single-mode fiber optic coupler alignment margin is 45 microns. The device's modulation bandwidth of 1.0 GHz makes it ideal for broadband wavelength division multiplexing systems, optical interconnection systems, and optical computing networks. Seven figures show a cross-sectional view of the array, a graph of the relationship among focal length, lens aperture, and microlens thickness, a schematic of microlens fabrication by ion-beam milling, an SEM photograph of the array chip, the set-up for measuring the pulse response of the photodiode, a 1 GHz optical signal response, and the pulse response for the photodiode. There are no tables.

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GaAs/AlGaAs Multi-Quantum-Well IR Detector With Wideband Response

95P60092B Shanghai HONGWAI YU HAOMIBO XUEBAO [JOURNAL OF INFRARED AND MILLIMETER WAVES in Chinese Vol 13 No 5, Oct 94 pp 377-380

[Article by Li Jinmin [2621 2516 7044] et al. of the CAS Institute of Semiconductors, Beijing 100083: "GaAs/AlGaAs Multi-Quantum-Well Infrared Detector With Wideband Response," supported by grant from NSFC; MS received 28 Jul 94]

[FBIS Abstract] An investigation of a 130-element GaAs/AlGaAs MQW IR linear-array detector with a wideband response is reported. The device is fabricated with a Riber-32P MBE system. At T = 80K, a spectral response curve for the detector array with FWHM = 4.3 microns has been demonstrated in a vertically incident operating mode based on a waveguide with a double-period grating coupler. At the response peak wavelength of 9.5 microns, a peak detectivity of 4.89×10^9 cm-$Hz^{1/2}$/W and a responsivity of 2.89×10^4 V/W have been obtained.

Three figures show a cross section of the MQW material and device structure, spectral detectivity for one of the detector samples, and a graph of responsivity vs bias. There are no tables.

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200mm-Diameter Large-Aperture KDP Crystal High Power Frequency Doubling Laser System

40100018A Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol A21 No 11, Nov 94 pp 853-859

[Article by Cai Xijie, Mao Jianhua, Chen Wannian, et al. of the High Power Laser and Physics Joint Laboratory, CAS and China Academy of Engineering Physics, Shanghai 201800; (MS received 11 Oct 93, revised 28 Dec 93)]

[FBIS Abstract] 200mm-diameter large-aperture KDP crystal high power frequency doubling laser system for LF12 TW [terawatt] facility has been developed. In the experiment of using doubling laser beam to target, the external frequency doubling conversion efficiency was kept over 60 percent when incident laser intensity was higher than 1.5 GW/cm^2. Its highest efficiency of up to 65.6 percent was obtained. The largest output energy is 223.4 J (0.527 μm) with the largest input energy 357.8 J (1.054 μm).

High-Power Laser Diode Array Side-Pumped Nd:YAG Slab Laser

40100018B Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol A21 No 11, Nov 94 pp 865-868

[Article by Zhou Fuzheng, Chen Youming, et al. of the Shanghai Institute of Optics and Fine Mechanics, CAS, Shanghai, 201800; (MS Received 1 Feb 94, revised 1 Apr 94)]

[FBIS Abstract] Pulses with energy of 3.5 mJ, repetition rate of 1-100 Hz and energy fluctuation less than one percent have been obtained from a slab Nd:YAG laser pumped by a quasi-CW 60 W laser diode array. The optical-to-optical efficiency is 15 percent and slope efficiency is 29 percent. The *Q*-switchings of the DPL involving A-O, E-O, and color center crystals and dye have been realized, respectively. The maximum peak output power of the laser is 100 kW.

Spectral Properties of Chromium Ions in $KTiOPO_4$ Crystal

40100018C Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol A21 No 11, Nov 94 pp 917-922

[Article by Guo Xiangyi, Yang Baocheng, et al. of the Department of Physics, East China Normal University, Shanghai 200062 and Ma Changqin, Jiang Dehua, and Wang Xuning of the Department of Chemistry, Shangdong University, Jinan 250100; (MS received 2 Mar 94, revised 14 Apr 94)]

[FBIS Abstract] The absorption spectra and excitation spectra at room temperature, the laser-induced fluorescence spectra and the fluorescence lifetime both at room temperature and liquid-nitrogen temperature of a Cr:KTP crystal are measured experimentally. On the basis of the results, the ligand parameters, absorption cross section, emission cross section and quantum efficiency (QE) of the active chromium ions are calculated. It is found that the chromium ions are in the weak ligand, but show strong electron-phonon coupling. The lower QE at room temperature is assigned to a strong nonradiative relaxation. No spectral character of the chromium ions of tetrahedron is observed.

Cr:LiSAF Monocrystals, Flashlamp-Pumped Laser Developed by Anhui Institute

95P60096A Beijing GAO JISHU TONGXUN [HIGH TECHNOLOGY LETTERS] in Chinese Vol 4 No 12, Dec 94 p 15

[Article by Tang Honggao and Zhang Shang'an]

[FBIS Summary] A new type of tunable laser crystal called chromium-doped lithium strontium aluminum fluoride (Cr:LiSrAlF$_6$, or simply Cr:LiSAF) monocrystal has been developed in an 863 Program project (No. 863-715-04-04-04) begun in 1991 by the CAS Anhui Institute of Optics and Fine Mechanics (AIOFM) in cooperation with the University of Science and Technology of China. This type of single crystal, which has promising applications in laser fusion, underwater detection and communications, laser range finding and laser radar, atmospheric optics, and laser biotechnology, is easy to frequency double as a "navy blue" light source and easy to pump (with a flashlamp, argon-ion laser, or diode laser). This high-quality single crystal, grown by pulling [i.e. Czochralski-grown], is 20-25 mm in diameter and 60-100 mm long.

In the course of their research, the AIOFM scientists used a ruby laser (6328-angstrom wavelength, red light) to pump the Cr:LiSAF crystal, achieving a laser output energy of 50 mJ. Recently, these scientists realized the first domestic flashlamp-pumped Cr:LiSAF laser output. They used a C-axis-cut Cr:LiSAF crystal rod 6 mm in diameter and 49 mm long, with both ends polished and plated with a thin film; Cr-ion concentration was 3 atomic percent. Flashlamp length was 60 mm, pulse width was 165 microseconds, power supply capacitance was 200 microfarads, laser cavity length was 27 cm, and output-mirror reflectivity was 59 percent. With an input energy of 92 J, the scientists achieved a laser output energy of 420 mJ, a slope efficiency of 1.26 percent, and a room-temperature continuously tunable range of 780-938 nm. Through advances in crystal growth, crystal processing, and pump technology, it is hoped that even higher efficiency laser output will be realized with a laser rod 6 mm in diameter and 7 mm in length.

State-Level Communications Systems Development Base Completed

95P60103A Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 10 Jan 95 p 1

[Article by Guo Zhongliang]

[FBIS Summary] The State Communications Systems Research and Development Base, the Chinese electronics industry's largest communications R&D facility, passed state-level acceptance tests conducted at MEI's Institute 54 in Shijiazhuang on 28 December 1994. This base, built with a gross investment of 82 million yuan, includes a digital stored program controlled (SPC) [telephone] switch industrial technology R&D center, a military communications and tracking/control systems R&D laboratory, a communications equipment integrated circuit design laboratory, and a communications systems software development laboratory. The overall facility has 11,000 square meters of research labs and centers and 377 new instruments and pieces of equipment.

The main focuses of the new base will be as follows: (1) digital SPC switch software and hardware R&D and batch production; (2) product design techniques, including CAD of digital and video circuits (50-70 percent of emphasis) and of intermediate-frequency (IF) and microwave devices (30-50 percent of emphasis); (3) communications systems software development; and (4) CAD/CAM techniques for new product development. Mainstream products such as VSAT [very-small-aperture terminal] satellite communications terminals, naval satellite communications stations, and microwave and mobile communications equipment will also be developed and manufactured at the new base.

Shenzhen Firm's Tianqi Intelligent Network Certified

95P60103B Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 10 Jan 95 p 1

[Article by Xiao Wei]

[FBIS Summary] The "Tianqi Information Link," an intelligent network system developed by the Shenzhen firm Tianqi [1131 1142] Electronic New Technology Enterprises Ltd., was certified by a panel of technical experts from the SSTC's Information Department and from the Industrial and Commercial Bank of China on 28 December 1994. This new system, an important step forward in the development of China's own information superhighway, is an interactive multimedia communications network consisting of intelligent information computers, client/server (C/S) super information network servers, stereo communications platforms, and object-oriented distributed databases. It is compatible with fiber optic telephone networks, digital data networks, satellite and microwave communications networks, packet data networks, mobile telephone networks, cable TV networks, integrated services digital networks (ISDNs), and all computer data networks. Telephone traffic, computer data, video signals, and faxes may be sent over the network. The Tianqi Information Link complies with international communications protocols and world communications network industrial standards [so that China can become part of the global information infrastructure]; it is an "information highway" systems network.

Shenyang Firm to Manufacture Northern Telecom's SDH Equipment

95P60103C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 20 Jan 95 p 1

[Article by Li Shanyuan]

19 Jan (XINHUA)—On 18 January, Canada's Northern Telecom Ltd. signed an agreement with the Shenyang Municipal and Liaoning Province posts and telecommunications authorities and with the Liaoning Pioneering Group to cooperatively manufacture SDH [synchronous digital hierarchy] transmission equipment and related communications products. This US$20.5 million joint venture, called Shenyang Northern Telecom Ltd., will annually produce 3000 sets of SDH transmission equipment for optical communications. This equipment will provide reliable communications platforms for the domestic information superhighway, and is currently made by only a few advanced nations such as the U.S., France, Canada, and Germany.

Feature on HT-7 Tokamak Research at CAS Plasma Institute

956B0021A Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 17 Oct 94 p 1

[Article by Cheng Yan and Peng Dejian]

[FBIS Translated Text] In October 1993, the "Chinese Science News" and other major Chinese newspapers reported that the superconducting Tokamak HT-7—the large scale nuclear plasma research facility of the Plasma Institute of the Chinese Academy of Sciences (CAS), together with other associated research plans have passed the evaluation by several renowned nuclear fusion scientists in the world. The circular body of the major equipment of H-7 was installed in May of 1994; the vacuum test was completed in the early part of June; and the cryogenic superconductor test run was successful on its first attempt on July 19. In its letter of congratulations to the Plasma Institute, CAS stated: the HT-7 "will ensure China to take its place in the frontier of the world's nuclear fusion research, and thereafter provide successful experience for developing super science in China under the current conditions of the country." It "not only shows that the staff of the Plasma Institute is highly responsible, but is also a capable and trustworthy team."

The entire set of HT-7 facility (includes auxiliary cryogenic system, power supply system and diagnostic system) is worth nearly 200 million yuan. However, the Plasma Institute spent only 25 million yuan building the facility. Normally, it would take 10 years to set up this type of installation, but the Plasma Institute only spent three years to complete the job. No wonder the experts who came to visit the institute remarked, "The building of HT-7 is almost a miracle."

(1)

In February 1990, Huo Yuping, an honored scientist, received a letter from the Kurchatov Institute of the former Soviet Union. The letter expressed that the Kurchatov Institute would like to send its superconducting Tokamak facility T-7 which had been shut down, to the Plasma Institute as a gift so that the two institutes could have better cooperation in conducting research. Huo Yuping, a physicist who had done research in the field of nuclear fusion in many countries, realized that T-7 was the third largest nuclear fusion Tokamak in the world; its superconducting coil is very suitable for realizing a quasi-stable plasma body, which is one of the most important areas in research on nuclear fusion. With this major facility, the Plasma Institute could make some unique contributions to the world's fusion research and would become a key player in the world's nuclear fusion research field. However, Huo also realized that in order for China to reach its scientific research target, the Institute had to carry out a thorough and risky modification of T-7, and at the same time the institute had already started to build a medium-size Tokamak called HT-U. Therefore, accepting the modification of T-7 meant that the institute had to give up the HT-U. This also meant that the institute should take a rugged and risky path with no return rather than an easy path. It was hard to decide which path they should follow.

After a careful and detailed investigation and discussion of the feasibility of the T-7 modification, the leaders and the key members of the scientific and technical staff finally made the decision to accept the T-7, and they intended to modify T-7 into HT-7 within 3 years regardless of what it would cost. Their decision showed their determination to devote themselves to Chinese nuclear fusion research and the confidence of their capability in scientific research.

(2)

The T-7 is an engineering simulation facility. At first, it was only used to prove whether it could realize superconducting performance. The experimental measures were very limited. The Plasma Institute decided to open extra windows in the main equipment and modify the internal vacuum chamber and the superconducting vertical field layer. Only after this thorough modification was the T-7 able to take its position on the front line of current nuclear fusion research.

The structure of T-7 is unique. It resembles a "life saving ring" which consists of five inner and outer circular thin shell layers. Each circular inner and outer layer was inserted together. To open each additional window, the five inner and outer layers had to be penetrated and every part of the main equipment had to be completely redesigned. In addition, this would cause the deformation of the circular body. Nevertheless, there was a total of 30 different sizes of extra windows that had to be opened!

The leaders of the institute decided firmly to solve the problems of the odd-shaped cross section bellows. These bellows were used to connect the inner and outer vacuum chamber, which meant connecting the most inner and the most outer layers of the "life saving ring." There were several different shapes of bellows, such as, "runway," "oval" and "dripping;" the process requirements for making these bellows are extremely strict. Even the factories specializing in the bellows business hesitated to make these types of special bellows. But the engineering and technical staff of the institute with a glorious tradition did not stop because of these difficulties. They experimented again and again, and finally came up with 6 different types of 26 large welded bellows with special-shaped cross sections. Not only did the new bellows have a great appearance, but their characteristics were far better than the old bellows of T-7. "The founder of the T-7", Professor Ivanov, praised the work with two thumbs up after his visit to the institute.

The inner vacuum chamber (the most inner layer of the "life saving ring,") is the place where the plasma moved in the experiments; the T-7 was unable to withstand high temperatures and was damaged severely by burning. The new design required a stainless steel lining and dozens of cooling water tubes to be welded on the wall of the inner vacuum chamber so as to provide protection to the inner vacuum chamber. This unique structure gives mobility and flexibility to the HT-7. However, since all the parts were made of stainless steel which will deform considerably during welding, it was almost impossible to install. The engineers and technicians worked closely with the welders. All the welding was completed successfully the first time.

The superconducting vertical field is the middle layer of the "life saving ring," which is also the most critical layer. In order to open more windows, the scientific research team redesigned and rearranged the 48 sections of superconducting coils which were originally tightly arranged. The coils were overlaid in 24 sections, the coil boxes were remade and the coil frames were reinforced. In the process of assembling, the vertical field and the inner and outer layers (two layers) were squeezed together many times, causing a threat to the insulation; thus they had to readjust again. In this way, the research team made every effort in modifying more than 100 places of the five inner and outer layers during the assembly process; the design requirement was finally met.

The other important task for the superconducting vertical field layer was to install the liquified helium piping system. The superconducting vertical field layer had more than 2,000 joints, which are subject to a liquified helium temperature (4.5K) under working conditions; these joints needed to be welded from all directions at the site. Since there are strict technical parameters required for the special welding of the superconducting bus connectors, and without the special welding equipment, the construction workers had to experiment again and again to develop a satisfactory welding procedure. The welding of all the liquified helium piping joints was completed after overcoming numerous difficulties.

(3)

While redesigning the main equipment of T-7, the Plasma Institute was also working hard on the construction of the foundation, rebuilding the cryogenic system and installing the power system, etc.

—Within a year they completed the construction of a cryogenic facility having an area of 1,320 square meters and a height of 13 meters; they also prepared the site for installing the major equipment and the laboratory control room, and rebuilt and modified several laboratories.

—After 2 ½ years of hard work, they set up and successfully test ran two sets of liquified nitrogen systems and two sets of helium systems. These systems are capable of producing 600 liters of liquified nitrogen and 300 liters of liquified helium per hour; the production output respectively reached and surpassed the performance parameters of the former Soviet Union's system. The liquified helium system ranked No. 1 with respect to the scale and total output in China.

—It only took 2 years to successfully install the large HT-7 power system. Through careful calculation and strict budgeting, almost 100 thousand yuan have been saved.

The working strategy of alternately doing many things at one time resulted in great success. On May 18, 1994, the huge "life saving ring"—the circular body of the main equipment which weighed more than 30 tons, was successfully lifted up and positioned on the iron core foundation. While celebrating the successful completion of the modification of the main equipment, other auxiliary equipment started running smoothly, which assured the successful test run on the first attempt on July 19. All these ensured successful superconducting on its first test run. The international evaluation group highly praised the HT-7. They thought it was "a facility with adequate design," and "there are many important issues worth studying" in it. Professor Ivanov listed the HT-7 as "one of the 10 or 12 best facilities in the world."

(4)

The job to modify T-7 into HT-7 was a struggle; numerous problems encountered in funding, manpower, technology and scheduling had to be resolved. For more than 3 years, the Plasma Institute spent half of its funds and had more than 100 key researchers working on the HT-7 project. The institute experienced an extreme shortage of funds. However, most of the scientific research members worked hard day and night regardless of the conditions and their salaries. The modification of the main equipment took 3 ½ years, and the personnel worked hard for that period of time. The international evaluation group praised the people who worked in the Plasma Institute highly: "their devotion to nuclear fusion research and their tireless working ethics will encourage each individual."

Large scale international support and enthusiastic support from different quarters domestically were the significant factors contributing to the success of the HT-7 project. Back in the '80s, the personnel at the Plasma Institute had developed the HT-613 and HT-6M Tokamak facilities through their own efforts; their unique work made a deep impression on their international colleagues. Thereafter, the institute received a large amount of international support. The French Atomic Energy Commission provided a 120 KW ac pulsed generator as a gift to the project. The World Laboratory provided computers and data sampling systems that were worth U.S. $1 million. The Belgium Imperial Military Academy supported the project with ion-cyclotron heating emission tubes. All this support resulted from the extensive and effective international cooperation based on their own strength. The enjoyable cooperation between the Plasma Institute and the Kurchatov Institute was also the most significant reason why the Plasma Institute received the expensive equipment as a gift from the Kurchatov Institute.

Thirty MeV Cyclotron Developed for Isotope Production

95P60099A Beijing ZHONGGUO KEXUE BAO [CHINESE SCIENCE NEWS] in Chinese 30 Dec 94 p 1

[Article by Zhao Zhiyang]

[FBIS Summary] On 6 December, the on-target beam current of the specialized radioactive-isotope-production cyclotron developed by the China Institute of Atomic Energy reached 30 million electron volts (MeV) and 370 microamperes, the highest values yet attained for this type of cyclotron. Some of the isotopes capable of being produced by this cyclotron include Co-57, Cd-109, Ga-67, In-111, Ge-68, Tl-201, C-11, N-13, 0-15, and F-18.

East China Expects Huge Power Supply

40101009A Beijing CHINA DAILY [BUSINESS WEEKLY] in English 12 Dec 94 p 4

[Article by Chen Qide]

[FBIS Transcribed Text] East China needs an expected 157 billion yuan ($18.5 billion) to expand its power projects over the next six years, according to a source in China's power generating industry.

Almost 70 billion yuan ($8.2 billion) should come from the central government, but the rest will come from overseas and local investment, said an official with Shanghai-based East China Electric Power Group Corp.

Current foreign investment in the sector comes mainly in the form of loans from the World Bank and the Asian Development Bank in addition to foreign government export credits and investment from joint ventures.

The anticipated funds are needed to hike generating capacity from 35,000 megawatts at present to 55,000 by the end of this century.

East China will consume about 260 billion kilowatt-hours by 2000. The maximum power load will be 43,200 megawatts.

To meet that demand, the region must accelerate growth in its power industry, the official emphasized.

Priority will be given to large and medium-size fossil-fuel power plants because of limited water resources.

Projects requiring work include the eighth phase of the Wujing Power Plant where two 600-megawatt units will be started.

Additionally, the Waigaoqiao Power Plant in the Pudong New Area will complete its first phase in 1996 and begin its second phase in 1997, with a capacity of 3,400 megawatts.

Installation of two 800-to-1,000-megawatt units in the Hangzhou Bay Power Plant is also under consideration, the source said.

"When completed, they will become a strong impetus to the local economy."

Meanwhile, a number of generating units with a capacity of 6,800 megawatts will be installed in Jiangsu's, Pengcheng, Yangzhou, Nantong, Wuxi, Nanjing and Changshu areas, the official said.

Zhejiang will install 5,500-megawatt units in Jiaxing, Beilun Port and Wenzhou. A number of 4,800-megawatt generating units are planned in Anhui Province.

The source said the corporation will build some medium-size hydraulic power stations in East China to make full use of the region's limited water power resources.

The most important hydropower project is the Tianhuangping Pumped Storage Station in Zhejiang's Anji County with six 30-megawatt units. It is funded through a $300 million World Bank loan.

Other hydropower projects will be located in Zhejiang's Tankeng city with three 200-megawatt units; Wulongshan with two 200-megawatt units and Anhui's Xiangshuijian with 1,000-megawatt units.

Nuclear-power projects are also in the planning stage, the source said.

They include the second phase of the Zhejiang-based Qinshan Nuclear Power Station having two 600-megawatt units, the province's Sanmenwan Nuclear Power Station with two 1,000-megawatt units and the Lianyungang Nuclear Power Station in Jiangsu Province with two 1,000-megawatt units.

Nuclear power stations are also being considered for Anhui Province.

Efforts have been made to import electricity from the Gezhouba Hydropower Station in Hubei Province.

The East China area will hire electric power from the Three Gorges Hydropower Station, Shanxi coal-fired power plants and Southwest China Hydropower plants.

The region's 1,000-megawatt units will be renovated as well within the period, the source said.

Construction of Lijiaxia Power Plant at Peak Intensity

956B0027A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 15 Oct 94 p 1

[Article by reporter Cui Junqiang [1508 6511 1730] and correspondent Li Junzhe [2621 0193 0772]: "Lijiaxia Hydroelectric Plant Construction at Peak Intensity"]

[FBIS Translated Text] Following the completion of excavations for the diversion tunnel, the main dam and the station buildings, the period of peak intensity of construction on the Lijiaxia hydroelectric plant, a key national project, has begun. A total of 1.6 billion yuan of the investment has now been implemented. The highest part of the main dam is now 65 m high, one-third higher than called for in the schedule. The hydroelectric dam, which is the largest dam in the Yellow River basin and has the most modern equipment, is rising rapidly in the 5-km gorge.

The power plant, which will have an installed capacity of 2,000MW, is in Qinghai Province, on the upper Yellow River. It is being built jointly by the central government and the governments of Shaanxi, Gansu, Ningxia, and Qinghai for a total investment of 5 billion yuan. The power plant is the first on the Yellow River to be built through solicited bids, and the technological requirements and the difficulty of the construction work have few if any parallels anywhere in China. When the Lijiaxia hydroelectric plant is completed, its reservoir will be able to irrigate 200,000 mu of farm land, resulting in an additional output of 60 million kg of crops every year. The power plant will produce an average of 5.9 billion kWh each year, which will be of critical importance in developing energy-intensive industries in northwestern China and in alleviating China's electric power shortage.

Dongfeng Power Plant Produces Electricity Ahead of Schedule

956B0027B Guiyang GUIZHOU RIBAO in Chinese 19 Oct 94 p 1

[Article by Xiao Hongteng [5135 3163 7506]: "Dongfeng Power Plant Unit 1 Produces Electricity Ahead of Schedule"]

[FBIS Translated Text] On the afternoon of 16 October, a celebration and commendation meeting for the ahead-of-schedule commissioning of the Dongfeng hydroelectric plant, a national key project, was solemnly held at the construction site. Members of the province leadership Chen Shineng [7115 1102 5174], Wang Siqi [3769 1835 7871], Yu Zhonggui [0827 1813 2710], Liu Yulin [0491 3768 2651], Yao Jiyuan [1202 4949 0337], and Wang Siming [3769 1835 2494], old comrade He Renzhong [0149 0088 0112], and provincial government economic adviser Xie Yanghui [6200 7402 1920], were present. Deputy Minister of the Energy Industry Wang Shucheng [3076 1859 6134] and eminent hydropower expert and vice-chairman of the board of the China International Engineering Consulting Corporation Luo Xibei [5012 6007 0554] were among the experts who made a special trip from Beijing to attend the meeting. The Dongfeng hydropower plant will have a total capacity of 510 MW. Construction is being organized by the Wujiang Development Corporation of Guizhou; the Guizhou Hydroelectric Survey and Design Institute, Ministry of Electric Power, and the Central South Hydroelectric Power Survey and Design Institute are in charge of design; and construction is being performed by the No 9 Hydroelectric Power Bureau. Since work at the site was begin on 21 October 1984, the builders have braved hardship and danger, have persevered stubbornly, have relied on scientific and technical progress, and have overcome construction difficulties that included karst caverns, faults, and underground rivers, to dam the river a year ahead of schedule. The time that elapsed between the beginning of work on the main project, in 1989, and 31 August of this year [1994], when the first generating unit, with a capacity of 170 MW, began generating power for the power grid, was four months shorter than the national evaluation standard, an achievement that is impressive to hydropower engineers both in this country and abroad. The provincial government held the commemoration meeting in order to conscientiously sum up and disseminate the successful experience of construction at the Dongfeng power plant and to evoke a universal spirit of perseverance and selfless devotion. Deputy provincial governor Yao Jiyuan read the "Decision Commending Meritorious Units and Individuals in the Ahead-of-Schedule Production of Electricity at the Dongfeng Hydroelectric Plant."

Provincial governor Chen Shineng said in his speech, "Guizhou has abundant energy resources, and there is superior synergy for the development of the hydropower industry. We shall further accelerate the development of the electric power industry and strive to have generating capacity reach 10,000 MW by the year 2000, building Guizhou into a major energy center of southern China." When representatives of the No 9 Hydropower Bureau and five other units that were designated Superior Construction Units of the Dongfeng Project, comrades Zhang Jiqi [1728 1367 3823] and Liu Keqin [2692 0344 0530], who were named Superior Organizers of Construction on the project, and Hu Dayun [5170 1129 0061] and four other comrades who were named Extraordinary Contributors to the project, went to the podium to receive their awards, prolonged applause broke out, expressing high admiration for the builders of the project.

Report on Dongfeng Power Station Construction Work

956B0027C Guiyang GUIZHOU RIBAO in Chinese 19 Oct 94 p 2

[Article: "Survey of Construction on the Dongfeng Hydropower Station Project"]

[FBIS Translated Text] At the Dongfeng hydropower station, with a total generating capacity of 510 MW and a long-term average output of 2.42 billion kWh per year, the first generating unit began successfully producing electricity on 31 August 1994. The Dongfeng hydroelectric station is the second large station in the Wujiang River cascade.

At the end of 1984, the first team of builders from the No 9 Hydropower Bureau arrived at the site to begin preparations. The river was dammed on 30 January 1989, a year

ahead of schedule. Shortly thereafter, by using staircase blasting and a prefracturing technique without a protective layer, 230,000 cubic meters of excavation for the foundation of the dam was completed in just over 3 months.

Beginning in January 1990, in two months' work, the pouring of the magnesium oxide low-swelling concrete for the foundation footings of the main dam was completed. By February 1991, more than 300,000 cubic meters of excavation for the two wings of the dam was finished. In July 1994, the pouring of 457,500 cubic meters of concrete for the main dam was completed. The overall product quality was high. Now, the Asia-Pacific region's tallest and thinnest dam, an asymmetrical parabolic doubly-curved cement thin-arch dam 25 m thick at its base, 6 m thick at the top, and 162 m high, rises imposingly above the gorge in the Yachihe section of the Wujiang River. The underground generator building is 105.5 m long, 21.7 m wide, and 51.0 m high. Underground rock excavation totaling 555,500 cubic meters was performed at the site. Excavation for the station buildings was begun at the end of 1989 and was completed by February, 1992, receiving a national hydropower construction quality award. On 21 July 1992, the pouring of concrete for the main station building was begun, and the installation of the generating unit was completed on 3 August 1994.

Test operation was successful on the first try, as was connection into the power grid. The flood relief system, consisting of a spillway on the left bank, the flood tunnel, and outer and inner relief holes on the dam, fully met flood relief conditions in July 1994. The grouting galleries at three levels on the left and right banks have a total length of more than 8 km. A total of 321,200 meters of curtain grouting was performed, which is a national record. Before power generation was begun, 260,000 meters of curtain grouting had been performed, and the water level in the reservoir is now only slightly more than 20 m below the normal level. The anti-infiltration curtain functioned normally in high water-head tests. The completion of the Dongfeng hydropower plant has provided abundant construction experience for the comprehensive development of the Wujiang River and in addition will give a major impetus to the economic development of the great southwestern zone of China. Yet another pearl on the Guizhou plateau is now sparkling brightly.

China To Begin Construction of Third Largest Hydropower Station Along Huanghe River

95P60058A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 9 Nov 94 p 1

[FBIS Translated Text] China plans to begin construction of the third largest hydropower station, the Gongboxia hydropower station, along Huanghe River. The other hydropower stations completed are Longyangxia and Lijiaxia hydropower stations. The Gongboxia hydropower station, which is located on the border of Xunhua and Hualong Counties in Qinghai Province, will have a total capacity of 1.5 million kilowatts, a total reservior of more than 600 million cubic meters, and a total investment of 4 billion yuan.

Construction of Largest Hydropower Station in Heilongjiang Province Begun

95P60058B Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 3 Nov 94 p 1

[FBIS Translated Text] The interception of waterflow in Heilongjiang Province's largest hydropower station, the Lianhua hydropower station, has been completed. The Lianhua hydropower station, which is located in the lower stream of Mudanjiang River, is the largest conventional hydropower station in Heilongjiang province; it is a large project designed particularly for the generation of electricity and flood control. The station is scheduled to begin operation by 1996, and it will have an annual output capacity of 550,000 kilowatts-hours.

THERMAL POWER

Haibowan Power Plant Phase 1 Construction Completed

956B0028A Hohhot NEIMENGGU RIBAO in Chinese 27 Oct 94 p 1

[Article by reporter Gao Ping [7559 1627]: "Phase 1 Construction on Haibowan Power Plant Completed in 18 Months"]

[FBIS Translated Text] The construction of a modern power plant in Wuhai, located in western China, has been completed in just 18 months. On 25 October, two 100-MW generating units at the Haibowan power plant stage 1 project and the associated power grid facilities were successfully completed. The rapidity of the construction, the low cost and high quality of the project, and the high management standards, all were at the top nationwide for the construction of electric power projects of this size. Leaders of the autonomous region Wang Zhan [3769 0594], Liu Zuohui [0491 0155 2585], and Xia Ri [1115 2480], as well as Zhang Cangong [1728 3503 0361] and Tu Ke [4499 0344], were present at the ribbon-cutting ceremony.

The Haibowan power plant is the first electric power enterprise in the autonomous region to operate on the joint stock system. Its long-range planned total capacity is 18 MW, making it a major component of Inner Mongolia's resource conversion strategy of "making coal travel overhead," as well as an important construction project of the region's power industry for the eighth and ninth 5-year plans and a key project for the provision of electric power to Beijing. When the construction of the Haibowan power plant was undertaken, a reformed "new plant, new system" approach based on joint-stock ownership and group ownership was used. The capital construction was performed under an expanded general contractor system in which the Haibowan Electric Power Contracting Corporation of Inner Mongolia was assigned the responsibility for quality management throughout the project so as to save on investments, improve project quality, and accelerate progress on the project. Construction of the Haibowan stage 1 project was officially begun in April 1993, and through the vigorous united effort of the construction units' employees, a record of "commissioning the plant and reaching rated performance in the same year" was

posted on unit 1, and a record of "attaining rated performance at the time of commissioning" on unit 2. Experts say that the Haibowan stage I project has been the most rapidly completed electric power plant construction project in Inner Mongolia and in the country as a whole and has also achieved the highest quality. In the 8 months since the Haibowan plant was commissioned, through a spirit of "conscientious work for the stockholders and creation of a top-flight enterprise," with high standards, strict requirements, and an increased emphasis on safe and enlightened work, full use has been made of the joint-stock enterprise effect; with one-third of the staff drawn from other power plants of the same capacity, profits of more than 20 million yuan and a labor productivity of more than 110,000 yuan per worker were achieved.

Deputy secretary of the autonomous region party committee Wang Zhan gave a speech at the victory meeting celebrating the completion of construction. He said that the rapid completion and commissioning of stage I of the Haibowan power plant and its rapid attainment of rated performance prove that the quality, technological capabilities, and management standards of Inner Mongolia's power industry construction organizations have made inspiring progress beyond the base that was already in existence and that it represents a crystallization of the efforts of the power industry workers throughout the autonomous region to make reform more thorough, to accelerate development, and to persevere for success. He stated that the use of the reformed "new plant, new system" approach, combined with a bold search for innovation, had provided valuable experience for the region's development, construction, reform, and opening to the outside and had clearly demonstrated the vigor and superiority of running enterprises as corporations, making the corporations into group operations, placing group operations on a joint stock basis, and using a diversified joint stock system. He also stated that the development of physical energy must be guaranteed by means of spiritual energy, and that all trades and professions must act in a spirit of vigorous joint effort and perseverance, overcome temporary difficulties, rouse themselves for vigorous effort, and forge ahead in the great effort to develop Inner Mongolia and make it prosper.

Waigaoqiao Power Plant To Begin Generating Electricity

956B0042A Shanghai WEN HUI BAO in Chinese 17 Nov 94 p 1

[Article by intern Cai Wenke [5591 7036 1356] and reporter Chen Libing [7115 2621 0393]]

[FBIS Translated Text] No. 1 unit of the Waigaoqiao power plant, one of Shanghai's ten major key national projects for 1994, has been fired up after completing the testing of its components.

Four 300MW units will be installed in the 1st-stage construction of the Waigaoqiao power plant. Over 5,000 electric power construction workers have been engaged in the project since construction began on 15 October 1992, and it is expected that the construction period will be foreshortened by 10 months and the project will join the grid ahead of schedule within a year. Plans call for the installation of two extra)large 600MW to 1,000MW modernized units to be installed in each of the 2nd and 3rd stages of construction, which will lift the total capacity of the power plant up to as high as 5,000MW and make it one of the largest thermal power plants in the Far East. It will be a modern power plant with world)class technology, and an standout project in China's electric power system.

Work on the No. 2 and No. 3 units is now in high gear and they are expected to go into operation in 1995.

Coal Will Feed Huge Demand for Power

40101010A Beijing CHINA DAILY [BUSINESS WEEKLY] in English 12 Dec 94 p 8

[Article by Wu Yunhe]

[FBIS Transcribed Text] China is hammering out a decade-long programme to intensity both its coal production and electricity generation.

To cope with spiralling domestic demand, the country is hoping to generate between 1,350-1,500 billion kilowatt-hours in the year 2000. Last year, China produced 820 billion kilowatt-hours of electricity, according to the State Planning Commission.

As a major raw material for power generation, annual coal production should climb to at least 1.5 billion tons by the turn of the century—an increase of 359 million tons from output registered in 1993, the commission said.

The government is calling for newly-installed power generating capacity to increase by 15 million kilowatts annually during the Ninth Five-Year Plan period (1996-2000).

And the yearly increase in the capacity of the country's newly-installed power generating units is expected to be 18 million kilowatts during the 2000-2005 period, the commission noted.

Development of coal production is a fundamental part of the country's long-term energy strategy, commission officials noted.

They added that eastern and central areas should maintain current levels of coal production, and the western part should considerably increase production of the bulky commodity in the years to come.

But southern coastal areas, however, should be encouraged to import coal from abroad to feed hyper-expanding demand and shortages in local supply.

China is now taking steps to streamline the nation's coal mines and make them adjust to the new market order.

"After two years of struggle, China's coal industry has reduced its deficits and begun to adjust itself to the market economy," said Wang Senhao, Minister of Coal Industry.

In 1993, the ministry set a goal to turn around the industry from an across-the-board loss-making to a profit-making one within three years.

Together with staff cuts and diversified business, the mines have utilized more scientific practices to raise efficiency and capacity.

The ministry also hopes to lure more foreign investment to the sector, which it hopes to do by drafting a guidebook for foreign investors in the coal industry and holding an international bidding fair soon. It is also delegating export rights to enterprises in an attempt to expand coal exports.

State coal mines should continue to speed the process of shedding unnecessary employees and develop service industries and other businesses to provide alternative work for surplus hands, the ministry said.

Chinese Scientists Find First Evidence of Abiogenic Natural Gas Pools

946B0179A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 6 Aug 94 p 1

[Article by reporter Wang Jiannong [3769 1696 6593]: "Chinese Scientists Discover First Abiogenic Natural Gas Pool"]

[FBIS Translated Text] Wang Xianbin [3769 0341 1755] and his colleagues at the Lanzhou Geological Institute, CAS, a state key laboratory in the field of gas geochemistry, have used the well known Fischer-Tropsch reaction to obtain results further supporting the abiogenic origin of a natural gas pool that they have identified on the Song-Liao plain. There has not hitherto been a reliable, thorough publication anywhere in the world demonstrating the abiogenic origin of a gas pool. The discovery provides important evidence in support of the theory of abiogenic natural gas formation.

Since natural gas was first discovered, geologists and geochemists have universally believed that it was formed by reactions involving buried organic matter.

More than a century ago, French chemists enunciated the dissenting view that natural gas could be produced abiogenically. In the 20 years after 1877, the famous Russian chemist Mendeleyev further elaborated the theory. But until the middle of the present century, owing to a lack of evidence, the idea of abiogenic gas formation was regarded as erroneous.

In the last 30 years, scientists in many countries, including Wang Xianbin, have contributed new ideas to the theory of abiogenic gas formation. By making a comparative analysis of interstellar organic molecules, planetary atmospheres, and the organic matter of meteorites and investigating the theromodynamic stability of methane and other gaseous hydrocarbons, Wang Xianbin provided the first cosmochemical evidence of abiogenic natural gas formation and cast light on the evolutionary process by which natural gas is produced abiogenically in the earth's interior.

Wang Xianbin believes that hydrocarbons are the principal carbon-containing molecules of the solar system and that primordial hydrocarbon gases captured by the earth from the solar cloud when the planets were formed provided the principal source of material for abiogenic natural gas. As a result of the unique characteristics of the earth, these hydrocarbons became buried in the earth's interior, where, together with other plutonic gases, they migrate upwards through weakened zones of the crust, forming commercial natural gas deposits where conditions are favorable for pool formation. The amount of abiogenic gas is likely to be much greater than currently known world supplies of natural gas.

Although during the last 10 years scientists in many countries, including Wang Xianbin, have found abiogenic natural gas on mid-oceanic ridges and in geothermal zones at the margins of colliding plates, the amounts were so small that scientists were increasingly inclined to treat the existence of abiogenic natural gas pools as merely theoretical.

Wang Xianbin's most recent discovery, made early this year on the Song-Liao plain, together with results he obtained recently in an investigation the Fischer-Tropsch reaction, attracted the interest of geologists from the United States, Russia, Germany, New Zealand, and elsewhere when they were presented at the recently concluded Eighth International Conference on Isotope Geochemistry. Russian scientists suggested that U.S., German, Chinese and Russian scientists should jointly draw up a program of cooperation for further research in this field.

Some experts believe that if the abiogenic natural gas theory is proved, man will gain an "additional eye" capable of recognizing and finding subterranean gas resources.

Large-Scale Exploration in Taklimakan Yields Results

946B0179B Urumqi XINJIANG RIBAO in Chinese 29 Jul 94 p 1

[Article by reporter Li Dadong [7812 1129 2639]: "Large-Scale Exploration in the Taklimakan Bears Abundant Fruit"]

[FBIS Translated Text] As a result of several decades of difficult work, China's geologists now can use desktop computers to provide drilling crews with detailed on-demand information about the surface and subsurface geology of most of the Taklimakan desert. In the Luntai zone in the north of desert, the drilling crews have used geological data in the placement of 47 wells, almost all of which have produced oil showings. This success rate is on a par with advanced world petroleum exploration standards.

The Taklimakan desert, the world's second-largest mobile sand desert, located in the Tarim Basin of Xinjiang, swallowed up more than 20 ancient kingdoms. In the late 1970's and early 1980's, several desert geology exploration teams, made up of engineering and technical personnel from the Northwestern Geology Bureau of the Ministry of Geology and Mineral Resources and the No 3 Geological Survey Office of the former Ministry of Petroleum, went to the Taklimakan region to take on the heavy task of finding a reserve petroleum supply for China.

Preliminary statistics show that the petroleum geologists have performed two-dimensional seismic surveying on profiles with a total length of more than 160,000 km, three-dimensional seismic surveying in an area of 1,800 square kilometers and desert gravimetric surveys on profiles with a total length of more than 30,000 km, have set up 9 seismic profiles crossing the desert, and have performed 1:25,000 scale aeromagnetic surveys of the desert, as well as radiochemical explorations, special well logging studies, and other surveying work. In addition, they have emplaced more than 3,500 satellite global positioning system reference points in the desert, representing a density of 1 every 10 km, and have matched world standards for rapidity of positioning and for accuracy of coordinate-system conversion.

They have subdivided the region into seven basic structural elements, consisting of "three uplifts and four depressions," and have established stratigraphic and structural

databases for them. A basically complete body of structural data on the top several thousand meters of geologic strata beneath the desert has now been collected.

Senior engineer Liu Guoliang [0491 0948 2733] told us that the Xiaya and Bachu oil-containing uplift belts were identified in the western part of the desert and that an oil- and gas-bearing stratum 300 m thick was later found at Yueshan. Subsequent drilling located a high-productivity commercial reservoir of oil and gas in a stratum at a depth of 5,391 m, providing scientific well-siting data for the main petroleum development force.

Total Crude Oil Output Update

956B0030A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 13 Oct 94 p 1

[Article by reporter Gao Xinghua [7559 5281 5478]]

[Text] Beijing, 12 Oct (XINHUA)—China produced a cumulative total of 108 million tons of crude oil and 12 billion cubic meters of natural gas from January to September 1994, somewhat more than that same period of the previous year.

According to China National Oil and Natural Gas Corporation data announced on 12 October, China's output of on-shore crude oil in the first 3 quarters was nearly 104 million tons, fulfilling 75 percent of the annual plan; and production of natural gas was 11.7 billion cubic meters, fully 76 percent of the annual plan.

The China Off-shore Petroleum Corporation revealed that by the end of September, 4.67 million tons of crude oil and 270 million cubic meters of natural gas had been produced off-shore, surpassing last year's total annual output. This year, the total output of crude oil may reach 6 million metric tons.

China's oil industry strategy of "stability in the east, growth in the west" has been successful. Output from Daqing, Huabei, and Liaohe oil fields has equaled or slightly surpassed that of the same period last year. Output from newly developed oil fields in the west, such as Turpan-Hami and Tarim oil fields, are over 20 percent above the same period last year.

It is said that by the end of September China's cumulative exports of crude oil was over 14 million tons, fulfilling 74 percent of the planned annual export of 19 million tons.

Meanwhile, total investments in the Chinese on-shore oil industry increased by more than 35 billion Yuan, and the annual crude oil production capability grew by more than 7 million tons.

Natural Gas Reserves of Shaan-Gan-Ning Basin Verified

956B0030B Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 31 Oct 94 p 1

[Article by reporters Gao Xinghua [7559 5281 5478] and Chu Baoping [2806 0202 1627]]

[FBIS Translated Text] Xi'an, 29 Oct (XINHUA)—Natural gas reserves amounting to over 200 billion cubic meters have been verified in the Shaan-Gan-Ning Basin gas field, making it China's largest accessible on-shore gas field, and ranking it among the 115 oil fields in the world with reserves upwards of 100 billion cubic meters.

Experts say that this gas field is located in a singular pressure system covering a large area of mainly low-volume, low-yield gas fields. Its natural gas is an easily purified dry gas that is an excellent resource for the chemical industry. Getting the earliest possible economic benefit from the Shaan-Gan-Ning Basin gas field and recouping prospecting costs has made prospecting, development, and exploitation there the urgent mission of the moment.

Development and exploitation of the gas field has been listed by the State Planning Commission, and the Changqing Petroleum Prospecting Bureau is in the process of working out the total development plan. There is high interest among Beijing, Xi'an, and Yinchuan customers in the long-haul gas pipeline from the gas field to Beijing now being readied. It is estimated that an annual production capability of 3 billion cubic meters will be built before the end of 1997 and that will have a considerable impact on the urban consumption in those 3 cities and on their environments.

The Changqing Petroleum Prospecting Bureau is engaged in the exploration of the natural gas areas throughout the basin and peripheral area, and are struggling to raise the confirmed volume of reserves to over 300 billion cubic meters by end of century and secure a natural gas production capability of 5 billion cubic meters per year.

Two New Oil Fields Discovered in Junggar Basin

956B0030C Urmuqi XINJIANG RIBAO in Chinese 24 Oct 94 p 1

[Article by reporter Liu Feng [0491 2800]]

[FBIS Translated Text] Two new oil fields were discovered in the central Junggar Basin in October by the Jurassic-002 and Lunan-1 wells which brought up high output flows of industrial-grade oil.

The discovery of the Lunan and Shixi oil fields adds to the proof that the Junggar basin is rich in oil and gas and has great value for development. The Xinjiang Petroleum Bureau has so far found 17 oil fields in the Junggar basin, and it now has more oil fields than any other basin in the country.

Zhang Guojun, Chief Geologist at the Xinjiang Petroleum Bureau said that the possibilities for finding oil are vast and only one-fifth of the anticipated reserves in the 130,000 square-meter Junggar Basin have been confirmed so far.

Horqin Oil Field Begins Production

956B0030D Hohhot NEIMENGGU RIBAO in Chinese 28 Oct 94 p 1

[Article by Wang Kai, [3769 0418] and Li Huping [2621 5706 1627]]

[FBIS Translated Text] The second major oil field to go into operation in the Inner Mongolia after the Erlian oil field was built and and put into operation was the Horqin

oil field, which has a production capability of 1 million tons of crude oil per year. It was completed and in operation in early October, one year ahead of schedule, which earned accolades from the 6th Inner Mongolia Autonomous Regional Committee.

The Liaohe Petroleum Prospecting Bureau of the China National Oil and Natural Gas Corporation spent 2.5 billion yuan and carried on the research, exploration and development for more than a decade. In the last 2 years, with the aid of the regional leadership and relevant departments and over 10,000 oil workers who struggled long and hard, the Lujiabao and Horkang (extending from Horqin Zuoyi Houqi to Zhangqiangzhen, Kangping County in Liaoning Province) oil fields were completed, and great gains were made in exploring the Qianjiadian and Zhezhong oil fields. The Lujiabao and Horkang oil fields alone have estimated oil resources of nearly 400 million tons, 63.6 square kilometers of controlled oil-bearing areas and controlled oil geological reserves of approximately 78 million tons. The last reported controlled reserves at Lujiabao oil field itself are up to 150 million tons, and it has 267 crude oil extraction wells. In 1994 it developed a crude oil output capability of up to 1 million tons, with actual volumes up to 650,000 tons, and in 1995 the crude oil capability of Lujiabao oil field will be up to 1.5 million tons. To meet the targets for "transfer eastern oil westward, and turning local resources advantages into economic advantages" agreed upon by the Regional Party Committee and Government and the China National Oil and Natural Gas Corporation, assurances have been given that the annual crude oil processing capacity of the Hohhot refinery will be expanded from 1 million tons to 2.5 million tons; and the 2 small refineries in the eastern sector will be guaranteed a reliable supply of crude oil.

The Liaohe Petroleum Prospecting Bureau that undertook the crude oil prospecting and development on the Horqin prairie set up a peripheral basin prospecting company and Horqin oil field development company, adopted the principle of "Borrow to drill, sell oil to repay, and get things rolling"; brought in competitive mechanisms, and on every key prospecting and development project they abandoned the old practice of assigning units and setting work plans. They made frugal investments, opted for speed, quality, and tough standards; opened up foreign and domestic bids; gave preference to the best engineering outfits and let them do the whole project; wrested out the corrupt practices of the past where good and bad, big and small were all equal; brought workers' rewards into line with work volume, quality, and efficiency, and got every positive aspect out of the work force. The 10,000 plus oil workers who took part in the Horqin prairie oil field project braved sand storms, summer heat and bitter cold, summoned the revolutionary spirit, and wrapped up the project in good order.

The Liaohe Petroleum Prospecting Bureau, concerned as they were with effecting a rational development oil resources with benefit to the local economy, published an overall engineering plan for the construction of Horqin oil field that entailed the construction of an underground pipeline to ship crude oil to the Shaogen district of Ar Horqin Qi to load it onto vehicles and ship it westward to fulfill the "transfer eastern oil to the west" target, cut the transportation burden, reduce environmental pollution, and ease local highway transportation and railway congestion. The manner in which electricity, water, and roads were managed in keeping the "three ways open and even" in the oil prospecting and development area while adhering to the principle of minimizing damage to shelter forests and man-made grasslands was beneficial to the economic development and earned the admiration of all levels of the local government and the people.

Crude Oil Production in 1994

95P60059A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 10 Nov 94 p 1

[Article by Gao Xinghua [7559 5281 5478], Zhou Wei [0719 3555]: "Crude Oil Production in 1994 Is Expected To Reach 145 million Tons"]

[FBIS Translated Text] Official data indicate that by the end of October 1994, China's inland crude oil production reached 115 million tons, achieving 83.5 percent of the projected production, and oceanic crude oil production reached 5.28 million tons. Inland natural gas production reached 13.1 billion cubic meters, achieving 85.3 percent of the projected production, and oceanic natural gas production reached 300 million cubic meters. It is estimated that by the end of 1994, China's crude oil production will hit 145 million tons, and natural gas production will hit 16.4 billion cubic meters.

Update on Qiuling Oil Field in Turpan-Hami Basin

95P60059B Urumqi XINJIANG RIBAO in Chinese 1 Dec 94 p 1

[Article by Liu Feng [0491 2800]]

[FBIS Summary] The framework construction of Qiuling oil field, the largest in Turpan-Hami basin, has been completed. The new field isscheduled to begin production in August 1995, with an annual output capability of 1.4 million tons. Together with the other two large oil fields, Shanshan and Wenmi, the total oil production in Turpan-Hami bazin is expected to hit 3 million tons by 1996.

Curtain Rising on Second Phase of Qinshan Nuclear Power Plant Project

956B0029A Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 18 Oct 94 p 1

[Article by reporter Han Zhenjun [7281 2182 6511] and correspondent Li Tao [2621 7118]: "Curtain Rising on Second Phase Construction of Qinshan Nuclear Power Plant"]

[FBIS Translated Text] The curtain is rising on the construction of the impressive large-scale phase-2 Qinshan nuclear plant construction project. The China National Nuclear Industry Corporation announced that site surveying, tests and investigations dealing with the seismic, hydrologic, climatic and environmental aspects of the project have all been completed, evaluated and accepted. A total of 2.5 million cubic meters of civil engineering work has been completed, and the vehicular tunnel linking the phase 1 and phase 2 sites has been completed and is in operation. Major accomplishments have already been posted in the design and development of the equipment for the 600-MW power plant. The Qinshan nuclear power plant is the first Chinese-designed and Chinese-built nuclear power plant. The 300-MW phase 1 generating unit began furnishing electricity to the power grid in late 1991 and is now in commercial operation. Plans for the second-stage project call for two 600-MW generating units. Their steam supply system uses an international-standard circuit with a capacity of 300 MWe, which will also be usable in 1000-MW nuclear power plants. Completion of phase 2 will raise China's nuclear power plant technology to a new level and will be of major importance in giving China a domestically based, standardized nuclear power plant construction industry with series construction capabilities.

Recently, we learned from the China Nuclear Power Plant Research and Design Institute in Sichuan that the general drawings and the main component drawings for the pressure containment vessel, the steam generator, the pressure stabilizer, the reactor internals, and the control rod drive mechanisms have been completed. New progress has been made in the development of materials for the plant. The special steels for use in the containment are the successful result of 10 years of research. Special heat transfer tubes have been developed for the steam generator and are on a par with international standards. China is vigorously cooperating with France in the design of the nuclear island and the fuel elements.

Through the efforts of Chinese researchers, a successful start has been made in dealing with difficult technological points and key problems in the building of the 600-MW plant. The China Nuclear Power Research and Design Institute has drafted nuclear power standards that take account of both international nuclear standards and China's conditions, so as to standardize China's nuclear power industry as rapidly as possible. In order to provide fuel elements for the power plant, China has imported French technologies.

The Yibin Nuclear Fuel Elements plant has set up the largest domestic production line for nuclear fuel elements. The plant is currently producing refueling components for the Daya Bay nuclear power plant. Plant director Chen Baoshan [7115 1405 1472] told us that the nuclear fuel elements that are being produced for Daya Bay are also usable in 900-MW power plants and that they meet French technical standards. The enterprise is fully capable of producing fuel elements for 600-MW power plants.

At the Beijing Research and Design Institute of Nuclear Engineering, which is responsible for providing project design and technological services for Qinshan phase 2, the design of the main buildings for the nuclear island is proceeding smoothly and the design of facilities for the inspection, transport and storage of nuclear fuel elements has been completed.

Reliability Analysis of Electric Power System for Large-Scale NPP

40100019A Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 15 No 6, Dec 94 pp 486-492

[Article by Mei Qizhi of the Qinghua University, Beijing, 100084; (MS received 26 Oct 93, revised 28 May 94)]

[FBIS Abstract] Guangdong Daya Bay nuclear power plant is combined to the network and generates power within 1994. The reliability analysis of a large-scale nuclear power plant has been regarded as an urgent project to be brought up on the agenda. This lecture only discusses one of the critical accidents called whole-plant power-off of a million-kW-grade nuclear power plant, and puts forward some optimization methods to heighten the ability to resist this accident, moreover, to improve the reliability of the supply system and the security and economy of the nuclear power plant.

Risk Management System for a Nuclear Power Plant, Its Modeling

40100019B Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 15 No 6, Dec 94 pp 481-485, 492

[Article by Wang Yucheng and Xue Dazhi of the Institute of Nuclear Energy Technology, Qinghua University, Beijing, 100084; (MS received 26 Apr 94)]

[FBIS Abstract] The advantages of a risk management system for a nuclear power plant (NPP) in daily operation and maintenance of the NPP are introduced. The main purpose of this paper is discussing the approach of modeling for such a system. Also a new approach is put forward, which can make the model of the system desirable.

PV Technology and Power Supply in the Remote Countryside in China

956B0020A Beijing KEJI DAOBAO [SCIENCE AND TECHNOLOGY REVIEW] in Chinese No 9, Sep 94 pp 48-50

[Article by Jiang Jianmin, Senior Engineer, The Chinese Academy of Sciences in Gansu Province, Lanzhou 730000, and by Mao Yingqiu, Senior Engineer, The Energy Institute of the Chinese Academy of Sciences in Gansu Province, Lanzhou 730000]

[FBIS Translated Text]

1. Current Development Status of PV Technology

PV technology uses the photovoltaic effect to convert luminous energy into electrical energy; it was used as a power source for satellite communication in the early 1950s. The application was limited in the space region for a long time due to the high cost. The petroleum crisis in 1973 has expedited the research and development of energy recovery, in which the application of PV technology used on earth was a major subject. In the late 1970s, due to a drastic reduction in price, PV technology was widely used here on earth. People began to have a new understanding of the outstanding characteristics of the photoelectric power system (also known as photovoltaic power system): electrical energy can be generated on the spot, there is no need for long distance transmission; no environmental pollution problem, it is highly reliable, long life, simple to maintain and safe to operate, it is convenient to expand its capacity, it is easily compatible with other power sources and storage of energy is more convenient. The major problems include that a one-time investment is relatively high and it uses up a lot of floor space; also, its application is limited by the variation of sun light, therefore, the system generally requires energy storage components. However, the low maintenance cost, particularly the cost of power transmission is usually much lower than investing in building the electrified wire network. Therefore, the full life cost is not very high. This provides an ideal power source for remote countryside area where it is difficult to supply power in a normal manner.

Currently the most commonly used solar cell in the photoelectric power system is made out of different types of silicon, including monocrystalline, polycrystalline and amorphous silicon. Solar cells may be connected together, sealed and packaged to obtain the required electrical and weather-resistant characteristics for forming the solar cell module. The module of the solar cell, energy storage element (in most cases it is a battery) and control components are combined together to form the solar energy power system. In the Tropic of Capricorn and Tropic of Cancer zones, there are 5kWh of radiant energy from sunlight per square meter every day. Power systems that use solar cells of 40 peak watts (the capacity of the solar cell that generates one watt of power in a standard radiation of 1,000 watts per square meter is called one peak watt) can provide the power for three small florescent lamps to light for three hours every day, they can also provide the power for a radio or small black and white television sets to operate for three hours. The cell of a properly designed system can provide power for up to five days even during cloudy days.

During the last ten years, the annual production of the solar cell modules in the world rose from 5 million peak watts in 1981 to 52 million peak watts in 1991, and the price for each peak watt reduced from U.S. $14 in 1981 to U.S. $5 or $6 range in 1991. The United States and Japan are the major countries that produce the solar cell. In addition to using the PV system in the remote area for signal relaying in telecommunications, meteorological data collection and transmission, and providing electricity for the residence in the remote region, the United States also spends a large amount of money to develop the solar power system that links to the regular electrified wire grid for regulating the peak load. However, the testing of the latter was not very successful in the super large system (such as the 6 megawatt system in California). The domestic demands in Japan, Germany, England and France are very low, in most cases the system is delivered to the developing countries under government assistance programs. Australia, based on the fact that it is a scarcely populated area, has emphasized the development of different types of solar energy communication power systems (such as the microwave system, relay station, fiber optics communication system, solar energy telephone, digital control RF communication, etc.). The power rating ranges from 100 watts to 10,000 watts, enabling Australia to fully utilize its production capability and become the world's leader in PV application.

Currently, there are 100,000 families, farms, enterprises, public utility companies and commercial users in the world that are using solar power generating systems, the majority of which are small solar power systems (SSPS) for residential use.

2. Current Status in Promoting Photoelectric Power Supply System in Developing Countries

Currently, there are hundreds of millions of people living in conditions without electricity, and these people can only rely on lanterns and bonfires after dark. Although it is reported that the demand for power in developing countries is high in the 1990s, most of the newly developed power generation capabilities are targeted for urban areas. This is because of the dense population in urban areas which can lower the cost of electricity transmission and distribution. From the economical and political point of view, there are sufficient reasons to make the investment in urban areas. However, in remote areas where the population is sparse, the location is far away from the electrified grid and the electricity consumption is low, it is not economical to provide electricity in a normal manner. Over the past ten years, people have been experimenting and found that a solar power system is the only choice unless another means of power generation is available (such as hydropower and wind power). According to a survey and research carried out in India, the set up cost for low voltage power lines is U.S. $10,000 per kilometer for every thousand watts, so when 700kWh of electricity are transmitted per kilometer in a year, the electricity cost for each kilowatt-hour is U.S. $1; when 20,000kWh are transmitted, the electricity cost for each kilowatt-hour is U.S. 10

cents. The cost of power generation by diesel generator is very high when power consumption is low. The conclusion drawn by U.S. scholars indicates that photovoltaic power sources are cheaper than diesel generated power when the consumption is less than 5,000kWh. Therefore, solar power generation is drawing much concern internationally, and various types and sizes of solar power systems are being established in developing countries and experiments are being carried out. The results from the experiments indicate that, other than certain public facilities that are suited to the concentrator-type photoelectric power system, the SSPS for residential use outlasts the others. This is because the SSPS is a portion of the family's property and is well taken care of; the cases of upgrading the capacity of the electrical equipment in the concentrator-type system, extending the period of power usage which requires the cell to work excessively to a point that may damage the system will not happen. In the past few years, the common understanding of warmer weather and other environmental problems around the world provides a large amount of funding available in the application of pollution-free solar energy generation. Recently, the World Environmental Foundation Organization was very aggressive in promoting projects that combine solar power generation and environmental protection. The World Bank has considered merging the rural solar energy electrification plan and the energy guiding plan together in Indonesia, India and Sri Lanka. In supplying electricity to remote countryside areas, countries such as Indonesia and Sri Lanka in Asia, Kenya and Zimbabwe in Africa and Dominican Republic in Latin America all have gained satisfying results and experiences.

3. Problems Encountered in Supplying Electricity to Remote Countryside in China

Currently there are approximately 120 million people in China living in areas without any electricity, and there are 80 million poor people living in China. In fact, the majority of the two groups of people mentioned above overlap. A portion of the relatively rich people have not used electricity mainly because the location is remote and there is a lack of information. It is relatively easy for these people to start using electricity but it is hard for those living in the poor areas. Despite the facts that some of the poor villages are located near the large electrified grids, and the people in those areas are living close together, they are unable to share the cost for extending the electrified wire network. Therefore, to reduce and to eliminate the population living without electricity is just as big a job as to get rich in a poor area. Most of the time, the two issues are mixed together, and at times it is only one issue. We cannot imagine that, while entering the 21st century, there are still many people in China living in an environment that relies on lanterns for lighting, that there is no broadcasting or television and they are totally ignorant about the outside world. Currently, there is only a limited number of counties without any electricity in China; it is relatively easy to eliminate these counties. All one needs is to build a small power station (by diesel power generation or solar power generation). However, it is a difficult task to reduce the number of households that are living without electricity. The reason for this is that each of these residences has to be dealt with one at a time, and as the number of these residences are getting lower and lower, it will become more and more difficult to bring them electricity.

In recent years, while attention is being paid to providing power in the remote countryside around the world, the Chinese government is also very concerned about the issue. "The National 8-5 Assistance Plan to the Poor" [the 8th 5-year plan] has specified that the net income per capita shall reach 500 yuan and transportation and power shall be provided to the majority of the poor villages. For many years, the State Planning Commission, the Ministry of Electrical Power (the Ministry of Energy Resources or the Ministry of Water Resources and Power Industry), the Ministry of Agriculture and the State Science and Technology Commission, etc., have proposed various projects to provide electricity for the remote countryside. While expanding the existing electrified grid to a large extent, the use of new energy for generating power (such as the small scale hydropower, wind power, photoelectric and other combination systems) to the remote countryside has been tried and demonstrated, and considerable amounts of funding have been allocated for the programs.

During 1988 to 1994, the United Nations implemented a project called "Development of Photoelectric Technology in the Western Part of China" in the four western provincial districts in China. At the later stage of the project, the U.S. Photoelectric Foundation also funded promoting the use of SSPSs in the impoverished area of Gansu Province. Not only do these types of work advance our level of research and the quality of the photovoltaic system, they also enhance our knowledge in providing power to the remote countryside and in the production of photovoltaic power sources.

Nevertheless, all the studies and efforts in the past have not contributed to a completed successful experience in the issue of providing electricity for the remote countryside. Some of the existing successful methods are still deficient. Therefore, it is necessary [for us] to explore deeply the economical, political, technical and operational aspects so as to expedite the process of providing electricity to the remote countryside in our country.

From a macroscopic point of view, the economy in the midwest region of China is relatively behind. In recent years, the difference between the rich and the poor continues to grow. A scholar in China correlates this as the two legs of a person; one of the legs is strong while the other leg is broken. The 120 million people living without electricity and the 80 million poor people make up the broken leg of China. The developed countries may disregard whether the developing countries are dead or alive, but we cannot accept the attitude proposed by some of the western scholars: "let paradise always be paradise and let Hades always be Hades." We have to be concerned about the development in the western part of China. In addition, many foreign intelligent people have already recognized that the continuing poverty of the third world is going to limit the further prosperity of the developed countries. Therefore, we must pay attention and treat this broken leg and we have to understand and resolve the following 5 problems.

1. Major Points in Tackling the Key Problems

For many years we have been tackling the key problems of PV technology in our country, but the funding was mainly placed on solar cells, not on the other components and the overall system. The insufficient funds for the system was mainly used to "work" on the capacity of the system, thereby breaking the record of the capacity several times. In fact, there is not much practical meaning [doing that]. This is because China cannot produce some of the components (such as the invertor) for the large capacity system, therefore, the record-breaking, larger capacity system has to use imported equipment, and there is no innovation and breakthrough in the internal design of the system. On the other hand, the diversified, small scale system with a bright market future did not receive the amount of attention that it should have. In fact, even in developed countries, the number of the interlinked grid large capacity PV systems for regulating the peak load and the large capacity independent PV systems used for providing power to the remote countryside is not very high, accounting for a small ratio of the sales quantity of the solar cell modules. The promotion and implementation in foreign countries and China indicated that a small system for each family is the best choice for lighting in the rural area. A multiple-user system or a system to be shared by the village is not ideal because of fighting for the use of electricity, the result being the expansion of the capacity of the electrical equipment and the extension of time using electricity; these are done without consideration and finally the equipment is damaged. There are not very many successful cases. The writers believe that the manpower and funding for PV technology shall be focused on the SSPS. This is determined by the situation in China, otherwise the limited funding will be wasted. In fact, some of the countries that spend large amounts of money on research do not distribute the funding to "satisfy every" project. For example, in West Europe and Japan, only a small amount of manpower and funding is being spent on linking the grid system. Our funding is basically limited, we must "use the best steel to make the knife edge." We have a dominant position in SSPS technology, so basically there is no need to spend the money to tackle the key problems. Therefore, the money should be spend on the SSPS production technology and marketing.

2. Production Shall Be Linked With Marketing

China is a major country in the production of solar cells. Several production lines were imported during the '80s to give an annual production capacity of over 5 million peak watts; China once ranked third in the world, next to the United States and Japan. Nevertheless, China is only a small country in the manufacturing of solar power systems. Some of the components required for the system can only be produced in small quantity and the quality is poor, (such as the large capacity invertor and the deep draining cell). The factories that produce SSPS are basically small shops, and there is no market for them. Therefore, only a small portion of the gigantic photoelectric cell production capacity is being utilized; some of the factories have no choice but to produce photovoltaic cells for foreign countries in order to survive. Nonetheless, China possesses many years of experience in producing small solar power generation systems for the remote countryside; there are not any major problems with the components and the quality of the systems. The price for the photoelectric modules is currently stabilized at around 40 yuan for each peak watt; and the price for the system has fallen to around 100 yuan for each peak watt. Relatively speaking, the cost of photoelectricity is around 1 yuan per kilowatt-hour. Therefore, as long as the market demand is high, the production of photovoltaic systems and their components will grow. The quality will be enhanced and the cost will be reduced, thereby enabling photovoltaic production to grow into a large business. From this point of view, the photovoltaic market developed and formed by assisting the poor turns out to be promoting the employment and increasing the revenue of the country. The economic and social benefits are diversified, and the capital can be circulated and returned quickly. It is worthwhile to look at the experience of Australia.

3. Rural Area Electrification Plan and Helping the Poor

People living without electricity around the world can be divided into two groups. One group of people has money but no electricity, such as the majority of herdsman in the western part of China; it is easy to handle this group of people. They can be encouraged to purchase the small solar energy system by propagation, demonstration, sales promotion, installation and after-sales services. The other group of people have neither electricity nor money. For this group of people, we have to try to help them to make some money for solving their daily life problems, so as to release them from the "low income—no savings—unable to invest—no production—no income" circle. When their basic subsistence problems are resolved the use of electricity can then be worked on. Experience from promoting solar energy in thermal application at a certain place in China indicates that it is not a good practice to promote a new technology by just giving away [the equipment] for free. This is because farmers in general are not knowledgeable, they usually do not protect and use the equipment properly if they get it at no charge. Nevertheless, the experience from Qinghai Province and Inner Mongolia also indicates that subsidizing the purchase of small solar energy systems, when the local government budget allows, will receive very good result.

In the poverty area, helping the poor cannot be accomplished simply by giving away unless it is a natural disaster; the help must also offer development. The first task to offer the help with development is to let the people in poverty to recognize their own skills. A responsible staffer for an international help-the-poor organization, who has worked in the remote countryside in developing countries for almost 30 years, said, "Generally speaking, poor is not just a matter of money, and the problem with the poor cannot be resolved by just giving blood and money,... People can only reach what they believe they can do, no more and no less."

4. Who Will Tackle Photovoltaic Power Generation

Over the past, the State Planning Commission, the Ministry of Agriculture, the State Science and Technology Commission, the Ministry of Power Industry (Ministry of Energy Resources), help-the-poor offices, the "Three

West" Offices under the State Council (Gansu Province Hexi Passage, Dingxi District and Ningxiaxihaigu District) have worked on the electrification plan for the remote countryside. However, several ministries wanted to administer, and some of them were administering, but the scope of work was not clearly defined, and the funding was dispersed, so the result was not effective. According to our [the writers'] opinion, while fully utilizing the cooperation between all related ministries and strengthening the coordination between the Central and the local governments, allowing the State Planning Commission (to establish a specific division) to coordinate this task is undoubtedly logical. In order to administer the specific economic and financial activities, it is better to form a non-profit (or small-profit, amount of profit must be specified) organization (may also be called a foundation, an association or a development bank). The State will allocate a certain amount of funding and designate a certain goal and responsibility to the organization so as to warrant that the development plan for providing power to the remote countryside will proceed accordingly.

5. Increase Investment and Offer Favorable Policy

In recent years the total budget from the central and local governments used in PV technology to provide power to the remote countryside has been relatively small. In order to expedite development in the remote and the poor areas, the State should increase the investment. Currently, the regular grid wire network can be expanded to resolve some of the problems with the 120 million people living without electricity, leaving less than one third, or 40 million people who really rely on photovoltaic power; this amount represents 10 million households.

In order to shift the enthusiasm from different sources and to promote the acceptance of photovoltaic power in the remote countryside, the following approach is recommended:

(1) Encourage people from different places to request financial aid from international organizations and foreign civilian organizations. For those with foreign aid, domestic funding will be arranged with priority;

(2) Encourage local governments to use PV technology to solve the electricity problems in the remote countryside. Any investment made by the local government will be matched, at a designated ratio, by the central government;

(3) In order to maintain a balance among the provinces and districts in the entire country, the funding shall be arranged appropriately and tilted towards the border area, minority districts and poverty districts, particularly to the western part of the country;

(4) In order to encourage enterprises to develop new products suitable for the market, to provide a quality product at a lower price and to provide better service after the sales of the product, a favorable policy, such as subsidizing and lowering the tax rate, should be offered to the production enterprises of PV power systems. If possible, the enterprise and its products shall be selected by bidding. (Staff Editor Liu Xianshu)

Development, Utilization of Biomass Energy Using Fluidized-Bed Technology

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Abstract In this article, the current status of the development and utilization of biomass is introduced, the current application status and development trend of fluidized-bed combustion technology and fluidized-bed gasification technology for utilization of biomass materials are described. Experiments and practice indicate that fluidized-bed technology is one of the most promising technologies in the utilization of biomass energy.

Biomass energy is a very important source of energy in the world. According to statistics, about one-seventh of the energy consumption in the world comes from the utilization of biomass energy from plants. China is a big agricultural country; there is a great variety and large quantity of biomass materials generated in the agricultural and forestry production process. These biomass products include rice husk, straw, corncob, saw dust, chopped wood pieces, bagasse, melon seed shells, coconut shells, palm tassels and dry branches of trees. Statistics indicate that the annual production of straw in China is approximately 450 million tons, which is equivalent to 180 million tons of standard coal; the annual production of rice husk is approximately 50 million tons, which is equivalent to 20 million tons of standard coal; and the biomass produced in the processing of woods is approximately 24 million cubic meters, which is equivalent to 1.5 million tons of standard coal. About 70 percent of the energy consumption in the rural area of China is biomass energy, and more than a quarter of the total energy consumed in this country is biomass energy. It is obvious that if biomass energy can be utilized efficiently, it would be a significant contribution to expedite economic development in China.

The following are the advantages of the development and utilization of biomass energy: (1) Biomass is a regenerative material and its annual production capacity is very high; (2) it is a clean fuel, its sulfur content is very low and its nitrogen content is not very high either, therefore, the amount of sulfur oxide and nitrogen oxide released after combustion is very low, and in addition, biomass has a very low ash content, therefore, after combustion the dust content in the smoke is very low; (3) the biomass combustion process produces zero percent of carbon dioxide, and carbon dioxide produced after biomass combustion can be absorbed by the plants, thus the content of carbon dioxide in the atmosphere will not increased; (4) biomass is widely distributed and can be developed and utilized in areas where there are plants, which is particularly beneficial to areas where there is a shortage of coal.

The current problems that exist in the utilization of biomass are: (1) only a very small portion of biomass is used as raw material, fertilizer or forage in the industry; (2)

a portion is used inefficiently as cooking fuel in rural areas; (3) a very small portion is utilized in grate-fired combustion or gasification devices, and the combustion and gasification efficiencies are not very high; (4) the majority of the remaining biomass materials are stacked randomly; this not only creates a big waste, but also pollutes the environment.

It can be seen that developing a technology for the efficient utilization of biological waste would satisfy the growing demand of rural economic development. Not only will it generate a significant economic benefit, but also the standard of living for people in rural areas will be greatly enhanced.

1. Fluidized-Bed Combustion Technology Utilizing Biomass

Biomass has a high water content (some of it contains about 60 percent of water) and a low ash content. Some of the biomass (such as coconut shells) is relatively difficult to ignite. The use of grate-fired furnaces cannot provide a stable combustion; also, both the combustion efficiency and the furnace efficiency are relatively low. Therefore, biomass cannot be utilized efficiently. In a fluidized bed, a large amount of high-temperature bed material is available. For biomass that has a low ash content, poor fluidized characteristics or is difficult to ignite, fluidized-bed technology with media may be used. An inert bed material, such as sand and coal, which has fluidized characteristics matching those of biomass shall be selected and used as a fluidized medium so as to ensure the formation of a dense bed for stable combustion. The thermal energy stored in the dense bed is very high and the heat conduction is intense; therefore, it provides an excellent combustion condition for the biomass. For other biomass that is hard to burn, it is guaranteed to have a complete combustion because the biomass stays inside the bed for a longer time. For volatile or powdered biomass, a two-stage combustion can be used in which the top of the dense region (i.e., the sparse region) is furnished with secondary air. In this region, air-to-solid and air-to-air mixing is intensified so as to provide an efficient combustion. The circulating fluidized-bed combustion technology that became popular in the '80s made it possible for the enhancement of combustion efficiency. The circulating fluidized bed is formed by adding a cyclone separator at the outlet of the fire box or in the flue gas portion of a regular fluidized bed. By such configuration, the larger particle (containing higher carbon contents) flying out of the combustion chamber can be separated and fed back into the combustion chamber, thus the bed material (combustible particles) can be circulated. This is a very effective way to enhance the efficiency of biomass combustion. It can be seen that the fluidized-bed furnace is very suitable for burning biomass that has a high water content and a low thermal value. Also, this type of furnace will provide a higher combustion efficiency and a higher thermal efficiency; it is suitable for use with a wide variety of biomass materials. Therefore, the fluidized-bed furnace for combustion of biomass is one of the most promising technologies in the large-scale utilization of biological wastes.

Currently, fluidized-bed combustion technology is being used around the world for utilizing biomass energy. Take Sweden, for example, a country that uses a large amount of biomass energy; the use of biomass energy in Sweden is 16.1 percent (reaching 55kWh) of the total power consumption. To generate biomass energy, tree branches, leaves, forestry wastes, bark, saw dust and peat are sliced and chopped down first, then they are transferred to the thermal power plant for burning in the fluidized-bed furnace. Despite the fact that some of these fuels contain 50 to 60 percent of water, the thermal efficiency of the furnace can still reach 80 percent. In the United States of America, the use of fluidized-bed combustion technology to generate biomass energy has been developed with a broad scale. For example, the Idaho Energy Product Company of the U.S. can produce a medium fluidized-bed furnace for the combustion of biomass. The output of the steam furnace is 4.5 to 5t/h, and the output of the furnace for supplying heat is 1.06×10^7 to 1.32×10^8kJ/h. That series of furnaces have the following features: (1) No special preparation is required for biomass materials; (2) No pre-drying is required for biomass materials having a water content of less than 60 percent; (3) Desulfurization can be carried out within the fluidized bed; (4) Special equipment is provided to eliminate the heavy solid materials mixed with biomass materials; (5) Automatic operation; (6) Can be used to burn a wide variety of biomass—the furnaces have been used formally to burn multiple types of biomass, including dry wood pieces, shavings, wet wood blocks, olive pits, peat, brown coal, rice husks and waste from slaughterhouses; (7) Combustion efficiency is high, possibly reaching 98.5 percent; (8) Low-temperature combustion is used, the temperature in the bed is 649 to 982°C; (9) The furnaces have good environmental protection features: they are equipped with multiple-tube dust extractors and wet scrubbers, the concentration of dust in the flue gas is less than 24.41mg/Nm^3. R. Bilbao et al, staff at the Department of Chemical Engineering, University of Jaradoga [transliteration term] in Spain, have carried out in-depth research in the fluidized process for agricultural and forestry wastes. Laboratory experiments were performed to study the critical fluidized velocity and the minimum safety fluidization velocity using sand as a medium in a fluidized bed, and valuable reference data has been obtained from the experiment.

In China, remarkable results have been achieved in research and manufacturing of fluidized-bed furnaces for burning biomass materials. The faculty of the Thermal Energy Engineering Department at Harbin Institute of Technology started research on a bagasse-burning fluidized-bed furnace (capacity of 12.5t/h) in 1991; two units of the equipment have been produced by Changchun Furnace Factory and were sold to the Bayer Company of Germany. These two units have been transported to Thailand and have been operating efficiently. In addition, [the Harbin Institute of Technology] in cooperation with Changsha Furnace Factory has completed the research and manufacturing of a 4t/h fluidized-bed furnace for burning rice husks. This unit was placed in operation at the Hengyang Grain Depot at the end of 1993. [The institute] also started to work on the design of a 10t/h fluidized-bed furnace for burning wood pieces (wood dust) in 1992, and two of the units have been produced by Yingkou Furnace Main Factory. These units have been installed at Changrong

Plywood Company, Ltd., (a Taiwan-funded company located in the Dalian Economic and Technology Development Zone) and are used for heating during winter. More than a year of continuous operation, shows that the furnaces have sufficient output, stable operation even at low load, and a high overload capacity; the furnace is suited to a variety of fuels, including ground and chopped wood, to produce a stable combustion; it is easy to feed the fuel to the furnace, and it is convenient to adjust the first and secondary air supplies to the furnace. These provide a significant contribution to enhance the combustion efficiency; air distribution to the furnace is uniform to provide an efficient combustion, the wear-out of the buried pipe being insignificant. The temperature and quality of superheated steam comply to the production requirements. Thermal testing shows that the efficiency of the furnace is running at 83.8 percent. This efficiency rating is higher than the thermal efficiency of the 60t/h wood-burning furnace; the combustion efficiency of the furnace is 99 percent, which is the advanced standard around the world. The furnace has generated a significant economic and social benefit. Recently, [the institute] has received samples of palm tassel from Malaysian Haerda [transliteration] Company. The company has expressed its intention to purchase the 10t/h fluidized-bed furnace for burning the waste from palm tree processing. The analysis and testing of the samples are currently being carried out. In addition, there are numerous other scientific research institutes that carry out in-depth research on the fluidized and combustion characteristics as well as the medium mixing technology of biomass materials. These tasks will definitely promote the utilization of biomass energy with the use of fluidized-bed combustion technology.

2. Fluidized-Bed Gasification Technology

One way to utilize biomass energy efficiently is gasification technology (thermal decomposition) of biomass materials. Through thermal chemical reaction in the gasification device, biomass energy can be converted into high-quality combustible gas for combustion, heating and drying in cities and towns as well as driving equipment in power plants. Biomass gasification technology in China has seen rapid development over the past 10 years; research has been carried out to make [the gasification device] more compact, more practical, more reliable and easier to use. However, we are still in the testing stage of the small-scale, single-unit operation, in addition, there is still room for improving the quality and production capacity of the gas. Since the fluidized bed has a series of advantages such as sufficient mixing inside the bed, uniform temperature and excellent thermal conductivity, it has a remarkable advantage in the gasification of biomass. Currently, research on biomass gasification technology using a circulating fluidized bed is one of the most important subject [for us to work on].

2.1 Pressure-Boosting Circulating Fluidized-Bed Gasification Technology of Biomass

Circulating-fluidized-bed gasification technology of biomass materials features higher gasification strength, higher production capacity, better quality of the gas produced (more stable) and lower content of tars. Therefore, every country pays attention to this issue. Sweden, the country with in-depth research on biomass gasification technology, has developed a pressure-boosting, circulating, fluidized-bed gasification device. Such devices incorporate a new process utilizing circulating combustion gas and steam for power generation. Figure 1 [not reproduced] shows the flow diagram of the new process.

First of all, Biomass reacts with the gasification medium within the circulating fluidized-bed furnace (the furnace maintains a certain pressure); a high-temperature combustion gas (with a certain thermal value) is thereby generated. High pressurized gasification can promote the quality and amount of combustion gas. After filtering, the combustion gas is fed into the combustion gas turbine for power generation. The exhaust of the turbine is fed into an exhaust-heat boiler to heat up the water for generating the high-pressure, high-temperature superheated steam. The steam is then fed into a steam turbine for power generation. This new process can increase the efficiency of power plants by about 10 percent, also, the size of the gasification and purification equipment can be decreased. It is very suitable for large-scale, continuous industrial production. Sweden has completed the experiment and is transferring the technology for industrial application.

2.2 Normal Pressure Circulating Fluidized-Bed Thermal Decomposition Technology of Biomass

As the economy in the villages and towns develops and people's living standards are enhanced, the demand for energy and the application of gasification appears to be rising. The use of circulating fluidized-bed thermal decomposition under normal pressure can produce three types of secondary energy: combustible gas, thermal energy and electricity. Figure 2 [not reproduced] shows the process flow diagram for the generation of the three types of energy by use of the circulating fluidized-bed thermal decomposition under normal pressure.

The new process integrates the circulating fluidized-bed furnace and the heat-carrier fluidized-bed dry distillation furnace together. Thus combustible gas, thermal energy and electrical energy can be jointly produced in one system. In this process, the high-temperature circulating ash from the circulating fluidize-bed furnace is used as a heat carrier and is fed into the dry distillation gas producer to heat up the biomass, allowing the biomass to release its volatile content and produce dry distillate gas with a thermal value of more than 3,500 kcal/Nm^3. This production is used as a gas supply for the city. In addition, the dry-distillate biomass, together with the circulating ash, are fed back into the combustion chamber of the circulating fluidized-bed furnace for combustion, thereby generating electrical power. By this process, three types of secondary energy (combustible gas, thermal energy and electrical power) can be jointly produced from one system.

The production of combustible gas, thermal energy and electrical power utilizing biomass can be accomplished on the foundation of the joint production technology of thermal and electrical power. With a relatively low investment, a high quality of combustible gas can be obtained for residential use. To increase the utilization, biomass with a higher volatile content will be used for the production of combustible gas. The circulating fluidized bed may be used

for combustion of biomass with a lower volatile content. The entire system is highly efficient, energy conservative and environmentally safe. The application of this technology (to provide combustible gas and heating) has a significant and practical meaning to promote the living standards of people in the cities and developed villages and towns.

3. Conclusion

The development and utilization of biomass energy have a significant meaning in relieving the energy demand, promoting the economic development in villages and towns and protecting the ecological environment. Experiments and practice show that the application of fluidized-bed technology in biomass combustion and gasification has generated satisfactory results. The fluidized-bed technology is one of the most promising technologies in the large-scale, highly efficient utilization of biomass.

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